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GEOLOGICAL SURVEY

Hon. Robert Rogers, Minister; A. P. Low, Deputy Minister;
R. W. Brock, Director.

MEMOIR No. 30

THE
BASINS
OF
NELSON AND CHURCHILL RIVERS

BY
WILLIAM McINNES

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R. W. Brock, Esq.,
Director, Geological Survey,
Department of Mines.

Sir,—I beg to submit the following report on an area west of Hudson bay embracing part of the Province of Saskatchewan and part of the North West Territories of Canada; accompanied by a geological map on a scale of 16 miles to one inch.

I have the honour to be, Sir,
Your obedient servant,
(Signed) **William McInnes.**

Ottawa, 1911.

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THE BASINS

OF

NELSON AND CHURCHILL RIVERS

BY

William McInnes.

INTRODUCTION.

On account of the increasing demands for information about the country between Saskatchewan river and Hudson bay, and from the fact that a considerable amount of new information, both geographical and geological, in reference to the region, was available, it was deemed advisable to compile and publish the accompanying map sheet.

The map covers a rectangular area of about 220,000 square miles, having Fort Churchill at the northeast corner and Prince Albert at the southwest. The geological boundaries are laid down with accuracy only where they cross, or occur in the vicinity of lakes or rivers; elsewhere, owing to the extent of the region covered, they are necessarily only approximate.

In writing the descriptive report, the published writings of other explorers have been freely drawn upon for accounts of the parts of the district not visited by the writer.

A series of forty thin sections of the rocks of the district was examined under the microscope by Mr. Leopold Reinecke, and many of the names of the rocks used in the report are based on his descriptions.

HISTORY.

The historic period for the country adjoining Hudson bay may be said to begin with the visits of early explorers who sought the bay in the quest for a northwest passage to China and the Indies.

The inland region to the south was reached first by fur-traders from French Canada; Richardson states that the Indians of the lower Saskatchewan sold their furs to French Canadian traders as early as 1697. Permanent trading posts were not established until about the middle of the eighteenth century; one of the earliest being at the head of Cedar lake, where Verendrye built a fort in 1748 or 1749; the post at La Corne was founded in 1753, and that at the mouth of the Paskwia river in 1755. English traders do not seem to have reached this district until 1770 or a few years earlier, though the northern portion was reached by Henry Kelsey in 1691-2, and the Saskatchewan region in 1754-5 by Anthony Hendry, both of whom started from Hudson bay in the interests of the Hudson's Bay Company. This great Company was founded by merchants of England, who after a number of private ventures in the seventeenth century became convinced that an important trade could be established with the countries around the bay. A charter was granted by Charles II in 1670 to Prince Rupert and a number of associates, who were called 'The Governor and Company of Adventurers of England trading into Hudson's Bay,' giving them all the lands whose waters drained into the bay, and a monopoly of the trade of the region. Posts were established at the mouths of Nelson, Severn, Moose, and other rivers flowing into the bay, and from these for many years trade with the interior was carried on, through the mediation of the coast Indians. This policy was changed only after it was found that French traders, entering the country by Montreal and the great lakes, were interfering seriously in the inland trade, and the plan, which has since been pursued, of having an extensive system of inland posts, was inaugurated.

Cumberland House was built by Hearne in 1774, and there is a local tradition in the neighbourhood that the post at Moose lake was established a few years before that at Cumberland. Before the end of the century, posts had been established at a great number of places throughout the region. From that time to the present a large trade in raw furs has been carried on with the Indians of the district; for many years by rival English and Canadian companies. In 1808 the two Canadian companies—the X Y Company and the N. W. Company—united and continued as the N. W. Company, and between them and the Hudson's Bay Company a coalition was formed in 1821, and the name and charter of the last named Company was retained; the Hudson's Bay Company for the remainder of the century had only unorganized free traders to compete with. Recently Revillon Brothers, a French company, have invaded the field, and have established fur trading posts in the vicinity of most of the old forts of the Hudson's Bay Company.

SUMMARY OF GEOLOGICAL WORK.

During the summer of 1906 the writer descended Nelson river to Split lake and made an examination of the region lying between that lake and the Pas, on the Saskatchewan. During the course of the exploration Burntwood, File, and Grass rivers were examined, also the lakes lying north of the Pas. In 1907, Carrot river was surveyed, and the northern and eastern slopes of the Paskwia hills were examined. In 1908, a survey was made of Southern Indian lake, which occupies a large basin in the Churchill valley in latitude 58°, and the Churchill river was examined between that lake and Lac LaRonge. In 1909, Wapawekka lake was surveyed and a large part of Lac LaRonge; an examination was also made of Neweiben lake and part of Churchill river above the mouth of Rapid river. In 1910, Deschambault lake and river and Grassberry river were surveyed, and an examination was made of Amisk lake and of Candle river and the western part of Cumberland lake. (Montreal)

The remaining portions of the region covered by the map sheet have been examined more or less closely by many different explorers whose names will be given in the references. Outside the writer, those principally responsible for the geological colouring and descriptions are Bell, Cochrane, McConnell, Tyrrell, Low, and Dowling, all of the Geological Survey.

Bell's work was done in the years 1877 to 1880, and covered chiefly the valleys of Nelson and Hayes rivers and the Hudson Bay region; and Cochrane explored part of the country in the neighbourhood of Reindeer lake in 1881, Berens river in 1882, and, previous to that, in 1877, had explored Gods and Island lakes.

Low explored the route leading from Lake Winnipeg to Hudson bay, by way of Berens and Severn rivers, in 1885.

McConnell explored the country lying to the west of the area of the map sheet in 1889 and 1890, and, though his work does not appear on the map, it lay so close that it has been of value for purposes of correlation.

Tyrrell explored part of northwestern Manitoba in 1888 and following years to 1891; the country between Churchill river and Athabaska lake in 1892; and parts of northern Manitoba and eastern Saskatchewan from 1895 to 1899; and Dowling, between the years 1890 and 1899, made explorations in northern Manitoba and eastern and central Saskatchewan.

The work done by each of these, as well as by other explorers, will appear in the references throughout the report and in the bibliography.

TOPOGRAPHY.

The region, broadly considered, forms part of the extensive Pre-Cambrian peneplain of northern Canada, encroached upon, to the northeast, south, and west, by more recent, flat lying, sedimentary rocks. The peneplain surface has an elevation, in the northwestern part of the area, of from 1,300 to 1,500 feet above the sea, but gradually diminishes in height eastward to the broad declivity through which Nelson and Hayes rivers, and, in part, Churchill river, flow to the sea. In the neighbourhood of Sipiwesk lake, which lies about in the middle of the depressed area, the elevation of the surface above sea-level is about 600 feet. There are no high elevations, and the general level of the interstream areas is not more than 100 to 200 feet above the level of the streams.

The plateau has a gently rolling surface characterized by rounded outlines which have resulted from long continued and profound erosion. It is intersected by rivers and streams innumerable and is dotted with lakes of all sizes. The river valleys are moderately depressed, and are made up generally of chains of rock-bound basins which form series of lake-like expansions along the rivers, the water spilling over the lowest part of the rims and flowing from basin to basin with swift current or over a succession of rapids and falls.

The surface is wooded throughout, though, except in the valleys of the larger streams, the forest growth is of small size (Plate I). North of latitude 59° or thereabouts, the forest is mainly black spruce and tamarack of stunted growth, a growth which characterizes also the muskeg portions of the southern area.

To the northeast, where the horizontal limestones of the Hudson Bay basin overlie the older rocks, the surface is of the nature of a gently sloping, flat plain. The level character is due, in part, to the horizontal attitude of the rocks and, in part, to a covering mantle of boulder clay of somewhat uniform thickness. In this, and to some extent in the underlying, solid rock, the rivers have trenched narrow channels, which constitute the only breaks in the surface.

The overlap of the Cretaceous sediments to the south is marked for a hundred miles west of Lake Winnipegosis by the bold escarpments of the Porcupine and Paskwia hills, and farther west by the equally high but gently sloping outlines of the Wapawekka hills.

The country about Montreal lake and east of it is characterized by heavy accumulations of drift, which form somewhat prominent hills that reach heights of over 2,000 feet above the sea.

DRAINAGE.

The whole of the area under consideration, except a small tract in the northwest corner, is drained by rivers flowing to Hudson bay; of these, the Nelson and Churchill are the largest, the first named taking rank among the half-dozen largest rivers of the continent.

The Nelson, which empties from Lake Winnipeg into Hudson bay, is 1,660 miles in length, measured to the head of its longest tributary, the Bow, and drains an area of 370,800 square miles, of which about 313,000 square miles are in Canada. Its drainage basin embraces all the country, westward to the mountains, lying between the watersheds of Churchill and Athabaska rivers to the north and the Missouri to the south, and eastward to the head-waters of Albany river and to within 50 miles of the head of Lake Superior.

Its volume is computed to be 118,369[1] cubic feet per second at extreme low water, measured just below Sipiwesk lake and above the inflow of the large tributaries, Clearwater, Grass, and Burntwood rivers. The river is made up, by the union in Lake Winnipeg, of the Saskatchewan, Red, Assiniboine, Winnipeg, Berens, and many smaller rivers, and is augmented in volume after leaving the lake by receiving several large tributaries.

The water of the river is somewhat murky from suspended sediment, but gradually clears as it passes through the numerous lake expansions along its course, thus the amount of matter in suspension is 2·565 grains per imperial gallon below Lake Winnipeg and only 0·552 grains near the mouth. The water of the Saskatchewan, near Cumberland, was found to contain 16·60 grains of solid matter to the imperial gallon,[2] while that of the Nelson, below Sea-river falls, contained 17·1 grains,[3] and at its mouth, 12·528 grains.

The Churchill is 1,000 miles in length and has a drainage basin 115,500 square miles in area. The water along part of the river's course is slightly murky. It contains above the mouth of Reindeer river, 7·96 grains of dissolved solid matter to the imperial gallon. As is the case with the Nelson, the many lake expansions serve as settling basins, and the water, before reaching Hudson bay, becomes quite clear. Its largest tributary, Reindeer river, flowing from Reindeer lake and draining, as it does, part of the Pre-Cambrian peneplain, has very clear water, containing 2·02 grains of dissolved solid matter to the imperial gallon.[1]

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[1] Dept. of Public Works 1911. Nelson River, Report upon Reconnaissance Survey.
[2] Report of Progress, Geol. Surv., Canada, 1881-2-3, p. 6 H.
[3] Report of Progress, Geol. Surv., Canada, 1879-80, p. 78 C.

Hayes river, with a length of 180 miles and a drainage basin about 28,000 square miles in area, drains a belt along the eastern edge of the area mapped; its water is remarkably free from suspended sediment, and carries only 0·878 grains of solid matter to the imperial gallon.[2]

The tract to the northwest, above referred to, sheds its water westerly into Athabaska lake, to finally reach the Arctic ocean by Slave and Mackenzie rivers.

Lakes.

Lakes are very numerous throughout the area, particularly in the northern and eastern parts where inequalities of the surfaces, resulting from structural causes and from unequal decay and erosion of the older rocks, are not covered by later sediments nor filled, to the degree that they are in the south, by Quaternary sands, gravels, and clays.

Besides Lake Winnipeg, with an area of 9,460 square miles, mostly outside the area of the map sheet, the largest lakes are Reindeer, area 2,500 square miles; Wollaston, 900 square miles; Southern Indian, 800 square miles, and Etawney, which has not been explored, in the northern region; Lac LaRonge, 400 square miles, at the border of the Palæozoic area of sedimentary rocks; and Moose, about 400 square miles, and Cedar, about 300 square miles, in the Saskatchewan Valley region. Smaller lakes in great numbers are scattered over the region, many, which lie at a distance from any surveyed route, not appearing on the map. All the large lakes are shown and most of those that attain even a considerable size, but it may be assumed that over all the country not deeply drift covered, small lakes are everywhere plentiful.

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[1] Report of Progress, Geol. Surv., Canada, p. 6 H.
[2] Report of Progress, Geol. Surv., Canada, 1879–80, p. 77 C.

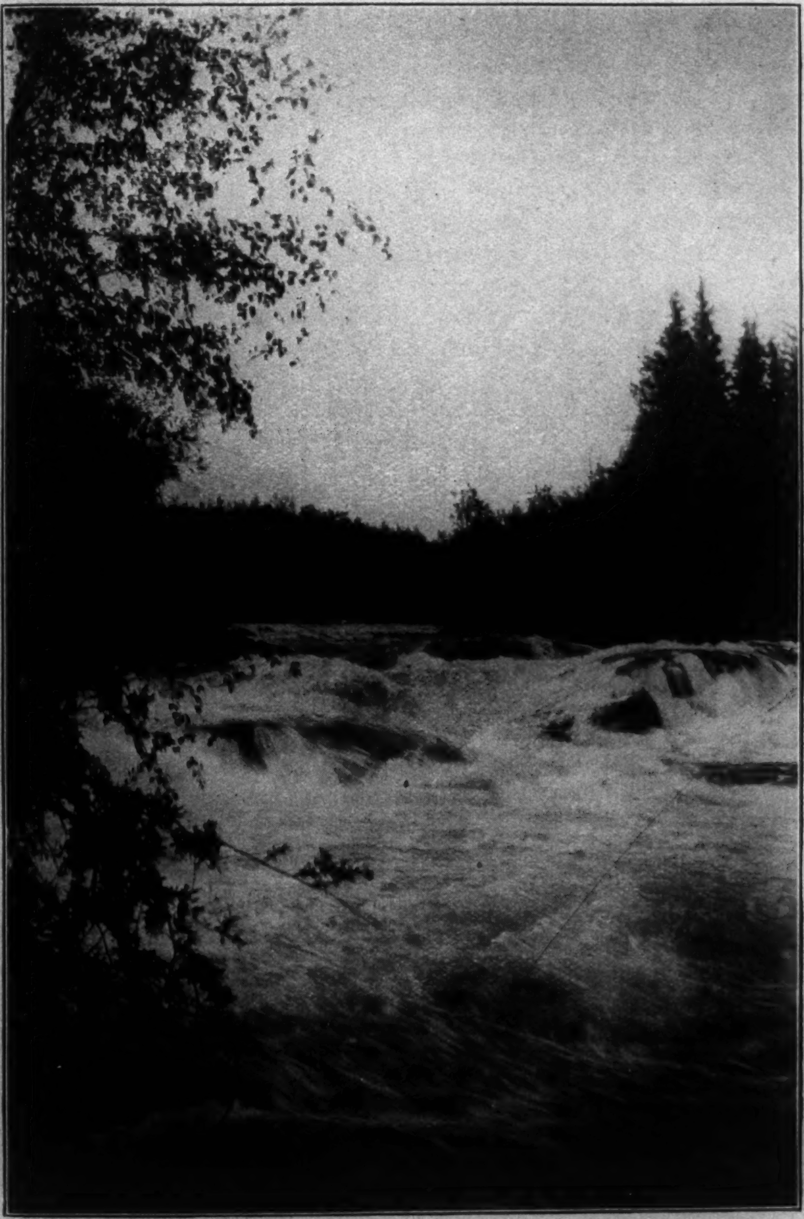

Photo by W. McInnes, 1910.

Sturgeon-wier river, Saskatchewan.

INHABITANTS.

The region is still in a wild state except in the southwest corner, where there are prosperous settlements, with the city of Prince Albert, population about 8,000, as a centre, and in the lower Saskatchewan valley, where a town is fast growing at the Pas, the temporary terminus of the Hudson Bay railway. Settlement is extending north also from stations on the Prince Albert branch of the Canadian Northern railway, into the Carrot River valley in the neighbourhood of Lost river.

The only other breaks in the wilderness are where a few houses cluster about the posts of the fur trading companies and the Missions.

Elsewhere, the country is inhabited by Indians, to whom are allotted certain reservations of land, but who for the most part make a livelihood by hunting over the unoccupied land. The Indians number about 4,600, divided into Swampy, Wood, and Plain Crees, of whom there are about 4,100 scattered over the region generally (Plate XV); Chipewyans, numbering perhaps 300, living in the northwest; Saulteaux, numbering 100, occupying reserves on Lake Winnipeg and near the head of Carrot river; and Sioux, numbering about 50, descendants of Sitting Bull's band, who are located on small reserve to the north of Prince Albert. On some of the reserves to the south small farms are cultivated, but generally over the region the Indians depend for a living upon hunting and fishing.

On the whole they seem to be slightly on the increase, though certain bands who are isolated from their kind by distance are decreasing in numbers. A few Eskimos come south from the barren grounds to the Hudson Bay post at Reindeer lake to trade their catches of furs for necessaries, and a few come down the west coast of Hudson bay to Fort Churchill.

FAUNA.

The region is well stocked with the larger wild animals of the deer family. To the north, in winter, barren ground caribou, *Rangifer groenlandicus*, are plentiful; large herds come as far south as Reindeer lake and the middle of Southern Indian lake during the period of their annual winter migration southwards. They were encountered by Tyrrell, in July, on Dubawnt river, about 200 miles farther north, in very large herds, numbering many thousand animals.[1] In early winter Indians from Churchill river travel north to intercept the travelling herds, to secure a supply of meat.

The woodland caribou, *Rangifer caribou*, is not uncommon in the wooded region to the south of that frequented by the barren ground variety.

Moose, *Alces americanus*, are common as far north as Churchill river and a little beyond, and are particularly plentiful in the part of the Saskatchewan valley bordering the low, swampy area. In the valleys of Carrot and Candle rivers they were found to be very numerous.

With them are found occasional Wapiti, *Cervus canadensis*; jumping deer, *Odocoileus hemionus*, and Whitetails, *Odocoileus virginianus borealis*.

Fur bearing animals, though not so plentiful as they once were, occur in fair numbers; they include:—

Black bear, *Ursus americanus*; otter, *Lutra canadensis*; wolf, *Canis occidentalis*; coyote, *Canis latrans*; lynx, *Lynx canadensis*; mink, *Putorius vison*; weasel, *Putorius* sp.; beaver, *Castor canadensis*; fisher, *Mustela pennauti*; marten, *Mustela americana abietecola*; wolverine, *Gulo luscus*; muskrat, *Fiber zibethicus*; skunk, *Mephitus hudsonicus*; and foxes, *Vulpes*.

Smaller animals include:—

Porcupine, *Erethizon dorsatum*; rabbit or hare, *Lepus americanus*; woodchuck, *Marmota monax canadensis*; and Red, Ground, and Flying squirrels; Little chipmunks; and gophers, lemmings, mice, voles, shrews, and bats.

Game birds, including wild geese, wild ducks, and several varieties of grouse, are fairly numerous. They all nest in the region in limited numbers wherever suitable breeding grounds are found. During the spring and autumn migration to and from the breeding grounds near Hudson bay, the lakes, scattered over the low lands of the Saskatchewan, fairly swarm with geese and ducks, and during these seasons they are taken in large numbers by the Indians. A large variety of other birds breed in the district; notable among them are pelicans and cormorants, which nest in great numbers on small rocky islets in the lakes north of the Saskatchewan (Plate III).

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[1] Geol. Surv., Canada, Annual Report, Vol. IX, 1896, Pt. F.

PLATE III.

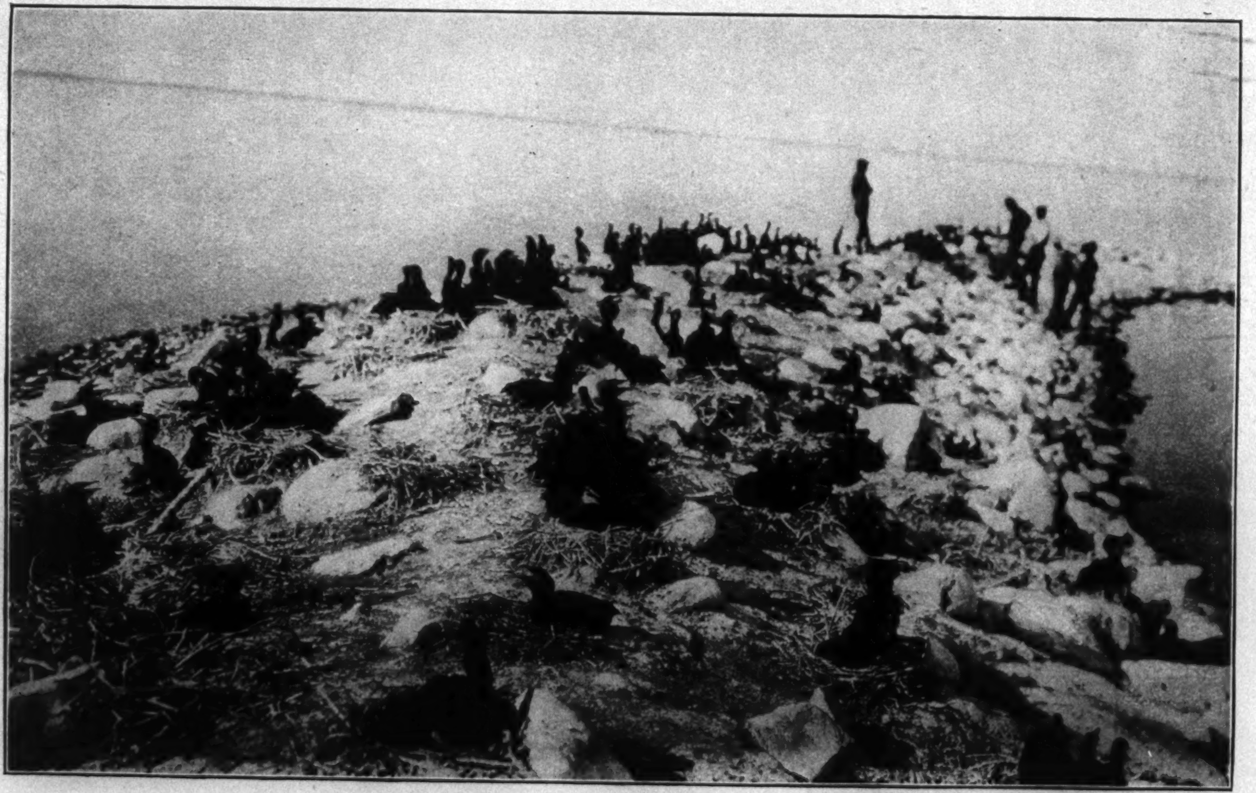

Photo by *W. McInnes, 1910.*

Cormorants' nests with young birds, on a boulder islet in Suggi lake; July 2, 1910.

The principal useful varieties of fish occurring in the inland waters are sturgeon, whitefish, lake trout, doré, pike, and goldeyes.

TRANSPORTATION.

The southern part of the area mapped may now be reached by the Prince Albert branch of the Canadian Northern railway, and by a branch constructed from the main line to the Pas on Saskatchewan river.

The proposed Hudson Bay railway when built will make the northern part more accessible, but the greater part of that area will, even after the building of the railway, be reached only by means of canoes and York boats or other craft suitable for navigating swift rivers, where numerous falls and rapids necessitate many portages (Plate II).

COMMERCIAL POSSIBILITIES.

The commercial possibilities of the region are great and varied. It contains, in the southern part, large areas of land suitable for settlement; its fisheries promise to be important and, under proper restrictions, could be carried on commercially without the depletion of the waters. The timber, though confined principally to a belt on both sides of the Saskatchewan and its tributaries, is an important asset. Over the northern portion the trade in furs is of very considerable value.

There is reason to hope that the region will be found to contain valuable minerals; it is traversed by several belts of Keewatin rocks (which probably include also areas of Huronian), and these, from our experience of like rocks elsewhere, may be looked upon as affording promising fields for the search for valuable minerals. Similar areas in central Canada have been found to contain many valuable deposits of ore, including ores of iron, nickel, silver, and gold. The minerals of the district are dealt with more fully in the chapter on 'Economic Geology.'

Fisheries.

Commercial fishing promises to be an important industry in the district, when, by the construction of the Hudson Bay railway, it is made accessible.

The lakes and rivers tributary to the Nelson and Churchill, as well as these rivers themselves, are well stocked with sturgeon, and in most of the lakes whitefish are plentiful. Lake trout may be caught in the clear water lakes, and doré and pike are abundant in almost all the lakes and streams.

The salt water fisheries of Hudson bay are sure to be of great importance. Although the fish occurring in the bay have not yet been studied thoroughly, it is known that many kinds suitable for food occur plentifully. Among the known varieties are whitefish and trout which are caught in the shallower parts of the bay, especially in the estuaries of the rivers; the Arctic salmon, which is plentiful along the east coast, and codfish, the presence of which has been established, though whether they are abundant or not is not known. Whether they are found to be plentiful or not, it seems probable that the bay might be successfully stocked with these fish, since it is known that cod may be readily propagated artificially, and the conditions of food supply and water are favourable. The deeper waters of the bay and straits have not been explored.

Whaling has been carried on profitably for many years in the waters to the north of the bay proper, and white whales or porpoise are plentiful in the bay itself.

Timber.

Though the district as a whole, with the exception of small tracts in the southern part, is wooded, there are but small areas within its boundaries in which the forest growth is of a size to be commercially of much value, and these are confined to the southern part and to limited stretches of river valley in the northern part. The timber tree of the region is the white spruce (*Picea alba*), though the black spruce (*Picea nigra*) attains a size suitable for pulpwood. The deciduous trees that attain merchantable measurements are the white birch (*Betula papyrifera*), the aspen and balsam poplar (*Populus tremuloides* and *P. balsamea*), and the tamarack (*Larix americana*).

Along the western side of the Paskwia hills and over the shoulder of those hills crossed by the Pacific Northern railway, there are extensive forests of white spruce which are now the basis of a large lumbering industry. In the region to the northwest of Prince Albert, lying, however, for the most part outside the limits of the area mapped, are extensive tracts of good spruce from which the

PLATE IV.

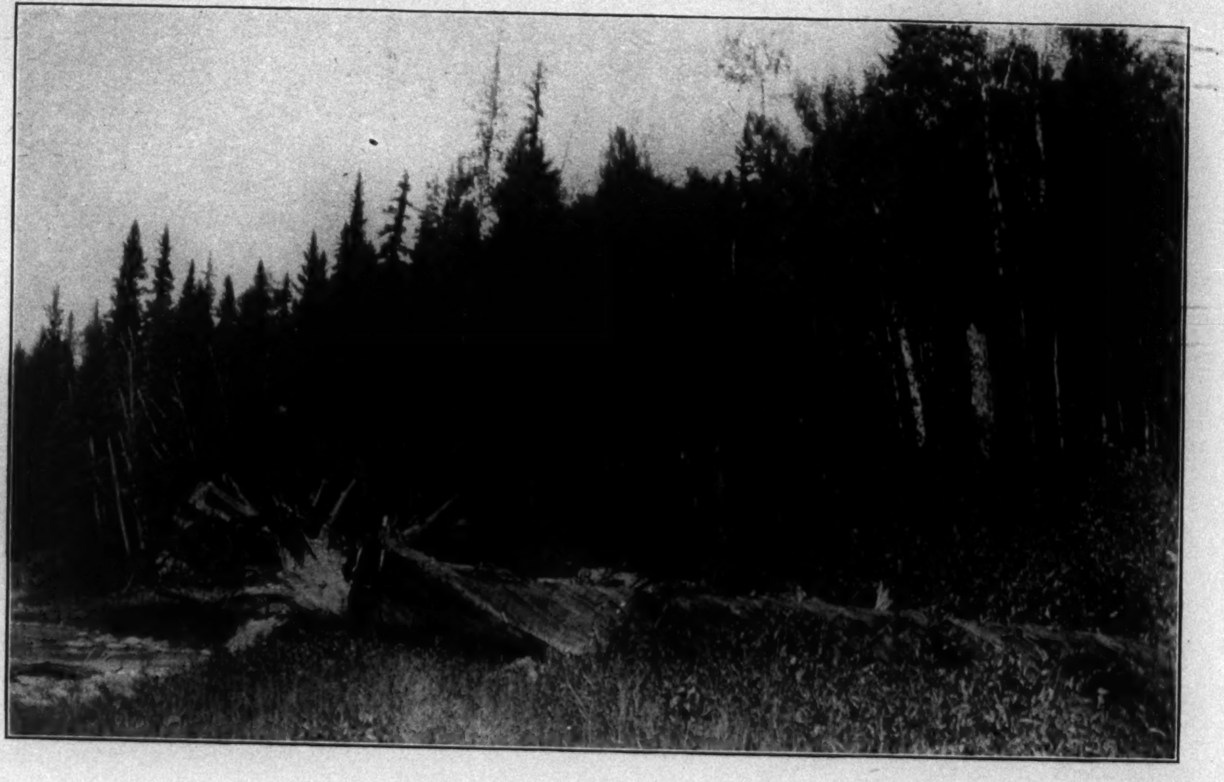

Photo by W. McInnes, 1910.

Uprooted trunk of white spruce, Candle river.

large lumbering companies of Prince Albert derive their supply of logs.

The principal tracts of good spruce remaining are situated in the Saskatchewan valley and in the valleys tributary to it, though small groves of good size occur along most of the streams, and scattered trees grow very large (Plate IV).

Forest fires have swept over most of the area at different times in the past and have destroyed much valuable timber. Only very wet, muskeg areas and tracts surrounded by lakes and swamps have escaped the repeated fires—the occurrence of two fires at intervals of 40 years was plainly indicated by the charred stumps on the uplands south of Burntwood river.

Carelessness on the part of travellers seems to have been the main cause of the fires, since violent storms with lightning are not common in the district.

The campaign of education being carried on by the Forestry department seems to be showing results in the greater care now exercised by many of the travelling Indians in regard to the spread of fire; and there is reason to hope that in time large tracts will be again reforested with trees of commercial size.

On the shifting sandbars and low islands and banks of the Saskatchewan, all along the portion of the valley east of Squaw rapid, the tall, straight rods of young willow, *Salix longifera,* form dense thickets, which are being renewed as the bars shift and as new land is being built up. There seems to be an opportunity here, now that access can be had to the river by railway, for the establishment of a willow-furniture and basket making industry.

Water-powers.

The total amount of power capable of being developed from the many falls and rapids which occur on the rivers within the area, is almost incalculable. Some of the rivers are of great volume and all, along parts of their courses, have rapid descents.

Of the rivers, the Nelson, by reason of its great volume and numerous falls, is the most important from the point of view of power development. Between Lake Winnipeg and Split lake, a distance of about 230 miles, the river has a descent of 240 feet, and between Split lake and the sea, 200 miles, a descent of 470 feet. The greatest fall occurs in the portions of the river between Cross and

Sipiwesk lakes, where there is a total descent of over 90 feet in 28 miles, and between Gull lake and the foot of Limestone rapid, where the descent is 396 feet in about 67 miles. There are a great many lake expansions along the course of the river, and between them, rapids and falls, to the number of fifteen or more, occur. Some of the falls offer excellent sites for water-power plants, and at several the vertical drop is considerable: at Ebb-and-Flow rapid there is a fall of 11 feet; at Whitemud fall, 30 feet; at Bladder rapid, where the whole river flows in one channel for the first time after leaving Playgreen lake, 11 feet; at Over the Hill rapid, 10 feet; at Redrock, 10 feet; at Grand rapid, 20 feet; at lower Gull rapid, 50 feet; and at Kettle, Long Spruce, and Limestone rapids, drops of 50 feet within a mile or so of distance.

When the great volume of the river is taken into consideration, amounting to 118,369 cubic feet per second at low water, or about four times the volume flowing over the Chaudière falls at Ottawa and one and a half times that at Sault Ste. Marie, it will be seen that the total amount of available power is very great.

Other high falls are Missi fall on Churchill river, just below Southern Indian lake, where the vertical descent is in the neighbourhood of 20 feet; Grand rapids, at the mouth of the Saskatchewan, with a descent of nearly 100 feet; a fall 30 feet in height on Rapid river near the Churchill (Plate V), and Manazo fall on Burntwood river where the vertical drop is about 30 feet. In addition to these, falls and rapids almost innumerable occur along the courses of all the rivers and streams of the region.

In a report on the water-powers of Canada, published by the Commission of Conservation in 1911, an estimate is made of the horse-power available at a few of the falls and rapids within the district. On the Saskatchewan the estimate is made for only two of the rapids, namely:—

Cole rapid, minimum H.P.	14,700
Grand rapid, minimum H.P.	80,000

PLATE V.

Photo by W. McInnes, 1910.

Fall on Rapid river, near the Churchill.

£2106—p. 12.

(Montreal R. – above La Ronge)

On the Nelson river the horse-power is calculated for eleven rapids, and aggregates 6,859,000, divided as follows:—

——	Approximate head, in feet.	Estimated horse-power.
Limestone rapid	85	1,140,000
Long Spruce rapid	85	1,140,000
Kettle rapid	96	1,290,000
Gull rapid	67	900,000
Birthday rapid	24	320,000
Grand rapid	20	270,000
Rapids above Sipiwesk lake	31	416,000
Bladder rapid	10·6	147,000
Whitemud fall	30	403,000
Ebb-and-Flow rapid	11	148,000
Rapids above Cross lake	45	605,000

CLIMATE.

Over so large an area as that included in the map there must necessarily be considerable variation in the climatic conditions. It may be said in a broad way, that all of the southern part of the area, including the broad valley of the Saskatchewan and most of the region lying between the Saskatchewan and Churchill river, is climatically suited for agriculture. The northern limit for cultivation follows approximately the 55° summer isotherm which crosses the central part of the area at about latitude 57° 30′; it may be placed at about the south shore of Southern Indian lake, for the central part of the area, somewhat farther south for the eastern part, and farther north for the western part.

The comparatively high latitudes, though they involve long and cold winters, give the compensating advantages of longer days during the summer months. During the three principal growing months this increased length of day gives to this northern area an amount of possible sunshine greater by 180 hours than that of central Ontario; converted into days this would mean more than ten days of added sunshine during these months, a very important consideration.

The following table gives the average maximum and minimum temperatures for the months of July, August, and September of the years 1906, 1907, and 1908, compiled from records kept during the explorations of those years:—

Locality.	Date.	Ave. max.	Ave. min.	
		1906 °	°	
Burntwood River valley..	July..........	75	54	
Grass River valley.......	August........	73	47	
Saskatchewan valley......	September....	62	44·5	Frost on night of 29th.
		1907		
Carrot River valley.......	July..........	74·4	52·1	
Carrot River valley.......	August........	66·9	47·9	
Carrot River valley.......	September....	57	37·1	Frost on 16th, 21st, and 26th to 28th.
		1908		
Churchill River valley....	July..........	77·3	50·6	
Southern Indian lake......	August........	62·1	45	
Churchill River valley....	September....	61·6	44·8	Frost 27th to 29th.

It may be of interest to add a more detailed table of temperature for the district between the Saskatchewan and Nelson rivers; and for comparison, a table, kindly furnished by Mr. Stupart, of the Meteorological Service, of temperatures at a number of points in Manitoba during the same season:—

Table of Temperatures.

Place.	N. Lat.	Date.	6.30 a.m.	Noon.	6 p.m.	Min. for 24 hrs.
	° ′	1906 Time.	°	°	°	
Valley of Nelson river.......	54—15	19	50	56	54	
" " "	54—30	20	50	55	52	
Cross lake...................	54—45	21	46	48	46	Strong N.W. wind and rain.
"	54—45	22	46	48	46	Strong N.W. wind.
Valley of Nelson river	54—45	23	46	61	66	
" "	54—45	24	58	68	64	
" "	54—45	25	52	68	72	

Table of Temperatures—*Continued.*

Place.	N. Lat.	Date.	6.30 a.m.	N on.	6 p.m.	Min. for 24 hrs.
Sipiwesk lake	55	26	58	70	72	
Valley of Nelson river	55—30	27	64	76	70	
“ “ “	56	28	60	78	76	
Split lake	56	29	66	70	65	Strong S. E. wind.
“	56	30	58	64	61	Strong S. E. wind.
Average for June			54½	63½	61½	
		July				
Split lake	56—15	1	54	76	....	
“	56—15	2	61	......	....	
“	56—15	3	60	72	72	
Lower Burntwood valley	56	4	62	84	80	
“ “ “	56	5	63	82	82	
“ “ “	56	6	64	74	72	
“ “ “	56	7	62	64	72	Rain 7 a.m. to noon.
“ “ “	55—45	8	64	72	72	
“ “ “	55-45	9	54	78	74	
Wuskwatim lake	55—30	10	50	80	82	
“	55—30	11	66	84	76	
Lower Burntwood valley	55—45	12	52	52	52	N. E. wind all a.m.
Footprint lake	55—45	13	47	52	50	N. E wind and rain.
“	55—45	14	52	56	60	N. E. wind and rain until noon
“	55—45	15	46	66	62	
Upper Burntwood valley	55—30	16	56	70	72	
“ “	55—30	17	60	76	74	
“ “	55—30	18	64	72	74	2 hours rain after noon.
“ “	55—30	19	60	72	74	
“ “	55—30	20	61	74	76	
“ “	55—30	21	57	67	66	Rain all day.
“ “	55—30	22	57	74	74	
“ “	55—30	23	60	74	76	
Burntwood lake	55—30	24	58	78	78	
File River valley	55—15	25	64	80	76	
File lake	55	26	58	84	78	
“	55	27	65	78	77	
“	55	28	62	76	76	
“	55	29	60	69	68	
“	55	30	58	66	73	
“	55	31	58	80	76	
Averages for July			58½	73	72	
		Aug.				
Methy lake	54—45	1	60	75	78	
BetweenMethy and Reed lake	54—45	2	59	68	66	
“ “ “	54—45	3	55	72	68	
Reed lake	54—30	4	55	72	70	
“	54—30	5	65	73	72	
“	54—30	6	65	73	72	
Grass River valley	54—45	7	64	82	80	
Wekusko lake	54—45	8	62	86	80	
“	54—45	9	60	76	76	

of added sunshine during these months, a very important consideration.

The following table gives the average maximum and minimum temperatures for the months of July, August, and September of the years 1906, 1907, and 1908, compiled from records kept during the explorations of those years:—

Locality.	Date.	Ave. max.	Ave. min.	
		1906 °	°	
Burntwood River valley..	July..........	75	54	
Grass River valley.......	August........	73	47	
Saskatchewan valley......	September....	62	44·5	Frost on night of 29th.
		1907		
Carrot River valley.......	July..........	74·4	52·1	
Carrot River valley.......	August........	66·9	47·9	
Carrot River valley.......	September....	57	37·1	Frost on 16th, 21st, and 26th to 28th.
		1908		
Churchill River valley....	July..........	77·3	50·6	
Southern Indian lake......	August........	62·1	45	
Churchill River valley....	September....	61·6	44·8	Frost 27th to 29th.

It may be of interest to add a more detailed table of temperature for the district between the Saskatchewan and Nelson rivers; and for comparison, a table, kindly furnished by Mr. Stupart, of the Meteorological Service, of temperatures at a number of points in Manitoba during the same season:—

Table of Temperatures.

Place.	N. Lat.	Date.	6.30 a.m.	Noon.	6 p.m.	Min. for 24 hrs.
	° ′	1906 Time.	°	°	°	
Valley of Nelson river.......	54—15	19	50	56	54	
" " "	54—30	20	50	55	52	
Cross lake..................	54—45	21	46	48	46	Strong N.W. wind and rain.
"	54—45	22	46	48	46	Strong N.W. wind.
Valley of Nelson river	54—45	23	46	61	66	
" "	54—45	24	58	68	64	
" "	54—45	25	52	68	72	

Table of Temperatures—*Continued.*

Place.	N. Lat.	Date.	6.30 a.m.	N on.	6 p.m.	Min. for 24 hrs.
Sipiwesk lake	55	26	58	70	72	
Valley of Nelson river	55—30	27	64	76	70	
“ “ “	56	28	60	78	76	
Split lake	56	29	66	70	65	Strong S. E. wind.
“	56	30	58	64	61	Strong S. E. wind.
Average for June			54½	63½	61½	
		July				
Split lake	56—15	1	54	76	....	
“	56—15	2	61	....	....	
“	56—15	3	60	72	72	
Lower Burntwood valley	56	4	62	84	80	
“ “ “	56	5	63	82	82	
“ “ “	56	6	64	74	72	
“ “ “	56	7	62	64	72	Rain 7 a.m. to noon.
“ “ “	55—45	8	64	72	72	
“ “ “	55-45	9	54	78	74	
Wuskwatim lake	55—30	10	50	80	82	
“	55—30	11	66	84	76	
Lower Burntwood valley	55—45	12	52	52	52	N. E. wind all a.m.
Footprint lake	55—45	13	47	52	50	N. E wind and rain.
“	55—45	14	52	56	60	N. E. wind and rain until noon
“	55—45	15	46	66	62	
Upper Burntwood valley	55—30	16	56	70	72	
“ “	55—30	17	60	76	74	
“ “	55—30	18	64	72	74	2 hours rain after noon.
“ “	55—30	19	60	72	74	
“ “	55—30	20	61	74	76	
“ “	55—30	21	57	67	66	Rain all day.
“ “	55—30	22	57	74	74	
“ “	55—30	23	60	74	76	
Burntwood lake	55—30	24	58	78	78	
File River valley	55—15	25	64	80	76	
File lake	55	26	58	84	78	
“	55	27	65	78	77	
“	55	28	62	76	76	
“	55	29	60	69	68	
“	55	30	58	66	73	
“	55	31	58	80	76	
Averages for July			58½	73	72	
		Aug.				
Methy lake	54—45	1	60	75	78	
BetweenMethy and Reed lake	54—45	2	59	68	66	
“ “ “	54—45	3	55	72	68	
Reed lake	54—30	4	55	72	70	
“	54—30	5	65	73	72	
“	54—30	6	65	73	72	
Grass River valley	54—45	7	64	82	80	
Wekusko lake	54—45	8	62	86	80	
“	54—45	9	60	76	76	

Table of Temperatures—*Continued.*

Place.	N. Lat.	Date.	6.30 a.m.	Noon.	6 p.m.	Min. for 24 hrs.
Wekusko lake—*Con*..........	54—45	10	60	72	68	
"	54—45	11	40	60	68	Light frost at night.
Grass River valley..........	55	12	60	58	76	54
" "	55	13	56	62	69	52
" "	55	14	60	91	83	54
Wekusko lake..............	54—45	15	65	78	81	56
"	54—45	16	60	68	74	58
"	54—45	17	49	78	78	47
Grass River valley..........	54—45	18	66	88	66	62
" "	54—45	19	57	55	52	56 Rain all p.m.
" "	54—45	20	45	62	68	42
Reed lake....................	54—30	21	36	68	67	32
"	54—30	22	47	78	63	38
South of Reed lake..........	54—30	23	50	78	71	34
" "	54—30	24	54	78	72	44
Cowan River valley..........	54—30	25	57	66	56	52 Light rain 5 to 10 p.m.
" "	54—15	26	52	62	60	40
" "	54—15	27	44	65	58	38
Yawningstone lake...........	54—15	28	43	49	53	42
" "	54—15	29	44	50	54	40
" "	54—15	30	44	58	59	43
Cormorant lake..............	54—15	31	56	63	64	46 S.E. wind, rain at night.
Averages for August..........	....	......	54½	70	68½	46½ Min. average from 12th to 31st.
Cormorant lake..............	54—15	Sept. 1	56	64	64	46
" "	54—15	2	56	61	61	42
" "	54—15	3	57	72	68	54
Atikameg lake..............	54	4	52	72	63	49
"	54	5	42	64	58	38
The Pas, Saskatchewan......	53—45	6	49	70	64	37
Atikameg lake..............	54	7	60	76	72	57
" "	54	8	50	70	72	48
Cormorant lake..............	54—15	9	60	67	65	55
" "	54—15	10	56	66	64	55
" "	54—15	11	51	54	58	48
" "	54—15	12	45	50	54	44
" "	54—15	13	37	51	54	36
" "	54—15	14	48	50	50	45
" "	54—15	15	51	50	50	47
" "	54—15	16	47	55	58	44
" "	54—15	17	56	64	60	55
" "	54—15	18	45	60	58	40 Light rain all day.
" "	54—15	19	51	68	60	50
" "	54—15	20	43	54	54	40
Atikameg lake..............	54	21	48	49	46	47
" "	54	22	43	56	46	42
" "	54	23	48	52	56	43

Table of Temperatures—*Continued.*

Place.	N. Lat.	Date.	6.30 a.m.	Noon.	6 p.m.	Min. for 24 hrs.	
Atikameg lake—*Con*..........	54	24	53	58	60	51	
" "	54	25	45	66	55	44	
Between Atikameg and Reeder lakes..................	54	26	43	56	46	42	
Reeder lake..................	54	27	44	68	60	32	
The Pas, Saskatchewan......	53—45	28	44	42	46	41	
" "	53—45	29	30	46	48	26	First killing frost.
" "	53—45	30	46	52	47	41	
Averages for September.....	....	......	48½	59½	57½	44½	
		Oct.					
The Pas, Saskatchewan......	53—45	1	34	48	42	34	
" "	53—45	2	45	56	48	42	
" "	53—45	3	45	50	46	42	
" "	53—45	4	34	48	42	30	
Saskatchewan river..........	53—45	5	35	53	46	......	Snow at night.
Cedar lake..................	53—15	6	40	42	44	......	Sleet at night.
High Portage................	53—15	7	38	48	46	......	Frost at night.

Summary of Temperatures.

	6.30 a.m.	Noon.	6 p.m.	Mean max.	Mean min.	Max.	Min.	Monthly mean.
July........	58·5	73	72	76	53	84	40	64·5
August.....	54·5	70	68·5	75	50	91	32	62·5
September.	48·5	59·5	57·5	64	44·5	76	26	54·3

The maximum temperatures in the above table are undoubtedly too low, as it was not possible, owing to the mode of travel, to keep a maximum thermometer continually set up, and the figures in the maximum column are merely the highest recorded at the time of observation. The July minimum in the summary is estimated and is probably low also.

The instruments used were 10 inch maximum and minimum thermometers, United States Weather Bureau pattern.

The instruments were set up under shade about 3 feet above the ground.

Abstract of Meteorological Observation, 1906.

MINNEDOSA.

1906.	TEMPERATURE.			MAX. and MIN. TEMP.				Monthly mean.
	7 a.m.	2 p.m.	7 p.m.	Mean max.	Mean min.	Max.	Min.	
	°	°	°	°	°	°	°	°
July........	58·3	77·4	72·2	77·4	54·5	87·5	41·0	63·8
August.....	55·0	72·6	70·3	76·4	51·0	95·5	33·2	63·7
September.	46·5	70·4	64·0	73·7	43·5	97·0	28·5	58·6

STONY MOUNTAIN.

	9 a.m.	2 p.m.						
July........	68·9	76·3	....	78·0	54·6	91·0	46·0	66·3
August.....	65·6	75·2	....	77·0	51·9	95·0	33·0	64·4
September.	....	....	....	....	....	....	....	....

HILLVIEW.

	7 a.m.	2 p.m.	9 p.m.					
July........	56·3	75·9	63·4	76·1	53·2	87·0	42·0	64·6
August.....	55·1	75·4	62·5	75·8	50·6	97·0	35·0	63·2
September.	47·3	73·1	58·2	74·1	44·1	98·0	28·0	59·1

BRANDON.

	7 a.m.	2 p.m.	9 p.m.					
July........	60·8	76·6	67·8	79·5	51·7	91·3	38·5	65·6
August.....	57·4	74·6	65·6	78·5	49·1	95·0	35·0	63·8
September.	47·5	72·7	59·1	75·1	41·9	100·0	26·0	58·5

Abstract of Meteorological Observation, 1906.—*Continued.*

DAUPHIN.

	MEAN.		EXTREME.	
	Max.	Min.	Max.	Min.
	°	°	°	°
July	79·3	55·4	91·0	41·0
August	78·1	51·1	94·0	35·0

BIRTLE.

July	78·3	53·3	86·0	40·0
August	75·8	49·0	94·0	34·0
September	73·0	41·7	93·0	28·0

AWEME.

July	84·4	54·9	97·0	42·5
August	80·8	53·0	103·0	35·0
September	77·8	45·5	101·5	29·0

OAKDALE PARK.

July	76·4	53·6	87·0	41·0
August	74·4	52·2	94·0	36·0
September	73·7	47·1	96·0	23·0

The best proof, perhaps, that the climate of this region, at least as far north as Churchill river, is not too severe for the pursuit of agriculture, lies in the experience of those who have made the experiment. Of the Saskatchewan valley, there is no need to write, since it is well established that in it the climatic conditions are quite suited for the growth of ordinary cereal crops.

In the part of the region which is still mostly wilderness there are necessarily few examples of actual cultivation to cite. At the posts of the Hudson's Bay Company, which are scattered through the country, some attempt is usually made, by the officer in charge, to cultivate at least a kitchen garden; and at a few of the posts, as well as at missions of the Anglican and Roman Catholic churches, in some cases more ambitious attempts at farming have been made. Thus, at Stanley, on Churchill river, wheat, oats, and barley have been successfully grown; in the Nelson River valley, wheat has been grown at Norway House and at Cross lake, and barley has been grown at Oxford House. Ordinary garden vegetables are grown annually at all the above-mentioned localities, as well as at Nelson House on Burntwood river, at Pukkatawagan on the Churchill, and at the posts on the shores of Hudson bay.

AGRICULTURAL LANDS.

Although over a large part of the region, especially in the northern areas, the lands suitable for cultivation are not extensive, very large tracts aggregating several million acres throughout the southern and central parts of the area are well suited for agriculture. Of these, parts of the southern tract along the upper parts of Carrot river and Saskatchewan valleys are already under cultivation, and settlement is extending year by year farther into the unoccupied portions. Before the completion of the northern branch of the Canadian Northern railway, most of this land was too remote from markets to be attractive to the ordinary settler; now, however, a large part of it can be reached by roads radiating from the railway at different points, and is thus brought within the category of land available for settlement.

Of this character is much of the area comprised in the valleys of Carrot and Saskatchewan rivers, though east of the Sipanok channel most of the land in these valleys is too low, in reference to the river banks, for proper drainage, and is subject to periodic floods from the overflow of the water of the Saskatchewan, when the river is in flood. Local weather conditions, though they affect the annual rise and fall of the water, are not the governing causes of the periodic floods. These floods are due to the melting of the snow in the mountains, where the river has its source, and may be expected to be better controlled in the future, when reforesting of the mountain sides has gone far enough to check the sudden run-off. There are areas suitable for cultivation to the north of Prince Albert, though most of the land in that neighbourhood is light and sandy. Tracts of limited extent occur about the shores of many of the lakes and in the valleys of the larger streams.

The most important spread of lands capable of being cultivated, beyond the Saskatchewan Valley area, is comprised in a basin underlain by lacustrine clays, which extends westerly from the Nelson river to near Burntwood and Wekusko lakes, in west longitude 95° 45′; northerly to the southern shore of Southern Indian lake, north latitude 56° 45′; and southerly to the escarpment which marks the northern edge of the Palæozoic sediments. The area of the basin thus defined is upwards of 10,000 square miles. Though this very large area cannot be described as all agricultural land, it contains about the proportion to be expected in a rolling country, of cultivable upland and valley bottom with interspersed areas of muskeg and tracts that are insufficiently drained. Near the centre of the basin the clays have a thickness of upwards of a hundred feet; they are thick-bedded and so uniform in character as to present the appearance of being without stratification. Where unmixed with surface humus the clay has a light buff colour and is unctuous to the feel, and in the central portions of the area, free from gritty particles.

From its composition, its homogeneous character, and the absence in it of marked stratification, together with the facts of its distribution, which cannot otherwise be easily accounted for, it is inferred that the clay was deposited at the time of the last glacial retreat, in a lake the waters of which were held up on the north and east by the ice walls formed by the retreating front of the glacier. On the east the ice front seems to have stood for a long period just east of the Nelson River valley, and on the north during the same period it formed a very irregular line lying, in a general way, just north of the Churchill valley easterly to Southern Indian lake.

Clay-covered Basin.

The valley of Burntwood river affords a good section through the basin, and the following description of the country passed through in the ascent of the river will give an idea of the general character of the country overlain by the lacustrine clays.[1] The river is a tributary of the Nelson, flowing from the west into a long westerly bay at the southerly end of Split lake.

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[1] See also Annual Report, Geol. Surv., Can., Vol. XIII, Pt. F.; Tyrrell, 1902.

The shores of the bay into which the river empties are made up for the most part of low, rounded ridges of gneiss, covered a few chains inland by clay and sand rising to a height of about 20 feet above the water level and beyond rising more gradually to about 50 feet, with occasional ridges of sand and clay that reach elevations of 70 feet or more. The forest growth is mainly spruce and tamarack mixed with aspen poplar and white birch and varying in age from quite young to 50 years.

Leaving the lake the banks of the river become higher, rising with steep slopes from water level to heights of 50 feet or more. They are composed of siliceous clay with little or no appearance of stratification. Wherever the protecting forest cover has been burned off, the clay becomes readily water-soaked and unstable, and small landslides are common.

Eight miles from the mouth, Odei river, a smooth flowing stream of considerable size, comes in from the west on the left bank. It occupies a well marked valley with bordering clay covered hills that rise to heights of 150 feet above the river. A clay mantle covers all the hills, except where an occasional cliff-like face of gneiss has been exposed by denudation.

The clay, lying deep in the valleys, and covering the summits more thinly, softens the surface contours and produces a country without high relief in which the original, rolling Pre-Cambrian surface has been made more even by the partial filling of the valleys.

A few miles farther up the river, above a series of short rapids, the banks are low and rise gradually to heights of from 6 to 20 feet above the water, extending inland with a moderate slope for 2 to 3 miles, where a height of about 100 feet is reached. Much of the land along this part of the valley is, apparently, well adapted for cultivation; the clay is quite free from boulders and is mixed, near the surface, with enough vegetable humus to produce a friable and seemingly productive soil. The gentle slopes of the surface give good drainage, and the open character of the forest and small size of the trees, mostly aspen, make the country one easily cleared for agriculture.

Few trees are left that are larger than 8 inches in diameter, 3 feet from the ground, and these mainly in the low, swampy portions which have escaped the fires that have swept repeatedly over the uplands. For the next 19 miles the river valley and the lands bordering it present the same general aspect. At this point the valleys of the main river and Odei river approach one another, separated only by a dividing ridge a little over a mile across and 150 feet high. The ridge is clay covered to its flat or gently rounded summit, where low knolls of the underlying gneiss project here and there from the clay cover. To the north, beyond the valley of the Odei the country is rolling and forested and the hills are clay covered to their tops, rising by gradual slopes to heights of about 100 feet above the intervening broad valleys, which are from 20 to 50 feet above the river level.

The forest is mainly spruce and tamarack of about sixty years' growth, the larger trunks having diameters of from 8 to 10 inches, but the general average size of the trees is not more than 6 inches. In the valleys occasional white spruce and tamarack trunks attain diameters as great as 18 inches. These are trees that have escaped destruction when the surrounding forest was burned, and their presence affords good evidence that, but for the occurrence of repeated fires, large areas would now be covered with trees of sufficient size for commercial lumber.

For the succeeding 28 miles, the river, flowing in a rock-bound basin, has the character of a long, narrow lake varying in width from half a mile to over a mile. Covering the well-rounded ledges of gneiss that form the actual shores, is the same mantle of clay, forming a country of very attractive appearance. A flat or gently rising plateau, lying from 20 to 50 feet above the water, extends back from the river for from 2 to 3 miles to another rise where the general level is increased to about 100 feet. Oft recurring forest fires have not only denuded this tract of its trees, but have swept it bare even of stumps, so that now it is clothed with an open growth of small birches, willows, aspen, and Banksian pine, with an undergrowth of vetches, grasses, and small shrubs. Just above is Manazo fall, where the river pitches over a ledge of gneiss with a vertical descent of 30 feet. A railway through this country might very well cross Burntwood river at one of the rapids below Manazo fall, where the ledges projecting from the shores afford good foundation for piers, and follow the plateau on the north side of the river to the valley of the Odei, which could be crossed at a point near the junction of the two rivers. At this lower crossing fairly deep water connexion with Split lake and the Nelson river, with their sturgeon fisheries, would be secured by either river.

Above Manazo fall the river expands to form a long, narrow lake for the next 10 miles of its upward course. A similar, rolling, clay-covered plateau extends back from both shores of the lake, rising gradually from the river to an undulating, higher tract, perhaps 100 feet above its level. The forest is very open, allowing the growth of a good surface carpet of grasses, vetches, and other vegetation. Diversified as it is, here and there, by small open tracts where the grass-covered surface is free of trees, this country, in many places, has quite a park-like aspect.

Throughout all the clay-covered region there is an almost entire absence of erratics; for miles no perched boulders nor transported material of any kind, other than the lacustrine sediments, are seen, and the underlying country-rock is deeply hidden under clay deposits of uniform character and great thickness. Where the wear of the stream has exposed sections of the clay it is seen to be very homogeneous throughout and stratified, if at all, only in very thick beds without conspicuous bedding-planes.

For the next 15 miles to Wuskwatim lake, the river has a quicker descent and its course is broken by several small rapids. The surrounding country is slightly higher than below, rising, in places, to about 200 feet above the river and it slopes up more steeply from the shore. From the south shore a clay-covered bench, one-fourth of a mile wide, rises with a comparatively steep slope to a height of 130 feet, and extends back from the river for miles at about that level, with a gently undulating surface, free from boulders or rock, except very rare exposures of the underlying country-rock. The low, flat land along the river is covered with a sixty-years old forest, mainly of Banksian pine and spruce. The higher plateau is wooded chiefly with spruce from 6 to 8 inches in diameter, with scattered Banksian pines, poplars, and white birches. Partly burned stumps standing here and there among the green forest, afford evidence of the passage over this area of at least two fires at short intervals apart and within comparatively recent years. The areas of muskeg on the uplands do not seem to be extensive, and no beds of gravel nor boulder ridges were seen. Indians who hunt in this district report that a similar, plateau-like stretch of country extends southerly to Grass river, with only gently swelling ridges and without high hills.

Wuskwatim lake, the next expansion, is 8 miles long by 4 miles wide, with a long, irregular bay extending westerly from its southern end. The water is but slightly turbid from suspended sediment and abounds in whitefish of good quality and small sturgeon. On all sides of the lake are large areas of nearly level, clay land, extending back from the shores at heights of from 15 to 50 feet above the lake level for several miles and, beyond, continuing at a level of a little over 100 feet. A mixed second growth forest, mainly aspen poplar, covers all the upland, while on the islands and on the low flats that border bays of the lake, white spruce and poplar with diameters of 12 inches form small groves. Grass-covered slopes, rising with very gentle gradients from the shores of the lake, give the country a most attractive appearance and render it, apparently, well suited for cultivation. The Indians of the section cultivate with success small garden patches of potatoes. Many of the bays of the lake are bordered with sand beaches, the first seen on the river, made up principally of garnets and other detritus of Pre-Cambrian rocks, but containing also, in smaller amount, limestone pebbles derived from the Hudson Bay Palæozoic basin.

For the next 30 miles up the river beyond Wuskwatim lake, the bordering country is of the same general character, clothed, for the most part, with a mixed second growth from 10 to 30 years old, but with, here and there, clumps of white spruce with tall, straight trunks a foot or more in diameter. Charred stumps, still standing here and there, bear evidence that over large areas in this region the forest, before being burned over, was made up of trees of large size.

Footprint lake, the next large expansion and the most northerly point reached by the river, lies in N. lat. 55° 45′. When the lake was visited in July, 1910, fields of potatoes, planted by Indians on its shores, were looking remarkably well; the vines were 11 inches in height and were about to blossom. To the north of the main lake, broad expenses of flat land extend back from the river on both sides, rising, within a distance of a mile from the shores, to 50 feet above the river. The greater part of the low, flat land and practically all the high land has been burned over within 20 years, and is now clothed with an open, mixed forest of small trees; the surface is free from gravel and boulders and is carpeted with native grasses, including such good meadow forms as the blue-joint (*Calamagrostis Canadensis* and *C. hyperborea*), and the wild rye (*Elymus dasystachum*). The open character of the forest permits a somewhat luxuriant growth of these grasses mixed with vetches, strawberry vines, and other plants, and broken by clumps of currant and gooseberry and other shrubs and bushes.

The land lying to the south of the most northerly bend of the river rises with a comparatively steep slope from the shore to a height of 60 feet above the river, and extends southwards in the form of a level, clay-covered plain with, at the surface, about 5 inches of friable clay-loam soil well mixed with decayed vegetable matter, gradually merging, downwards, into unmixed clay. The plateau has a gently rolling surface, the bottoms of the hollows, many of which show small areas of muskeg, lying at levels 40 feet lower than the summits of the ridges, and the highest land reaching not more than 100 feet above the river. For the first 6 miles south of the river the areas of muskeg, which are not sphagnum swamps but rather of the nature of grassy marshes, are comparatively insignificant in extent, the higher land, wooded with Banksian pine, poplar, and spruce, and diversified by many open, grassy glades, largely preponderating. Beyond this limit, however, a broad belt of wet, grassy, marsh land extends southwesterly across to the heads of the brooks running into Grass river below Wekusko lake and forms, for this part of the basin, the western limit of the clay-covered uplands, though in the valleys of the rivers and along the flanks of their bordering hills the clay land extends much farther west.

Concerning the whole of this extensive spread of clay-covered land, which extends from the valley of Nelson river westward to Burntwood and Wekusko lakes (west longitude 99° 45′), northerly to Southern Indian lake (north latitude 56° 45′), and southerly to the edge of the limestone escarpment, an area of about 10,000 square miles, it may be said that it is everywhere characterized by a heavy, clay soil entirely free from boulders. The lacustrine clays forming the soils of this region are composed of the rock flour scoured from the surface of the rocks by glaciers and carried in suspension by glacial streams to the quiet waters of a great lake, where they were deposited. The process of sedimentation being carried on almost continuously and little influenced by periods of flood, the clays are in very thick beds or almost massive. To the north, along the section afforded by Burntwood river, the clays are highly calcareous, while to the south, in the valley of Grass river and in the Saskatchewan valley, they are but slightly calcareous. It may be that the material was planed from the surface of the limestones of the Hudson Bay basin in greater amount in the northern portion of the area than in the southern portion, where the westerly trending glacier would pass almost altogether over Pre-Cambrian rocks, and that on this account the northern clays are more highly calcareous than the southern ones. This difference in the composition of the clays is of practical importance mainly from the fact that it indicates that the southern clays are probably well suited for brick making, while the northern clays are only doubtfully so. There is no distinct surface soil clearly separable from the clay subsoil; the one merges gradually into the other, the clayey character of the soil being strongly apparent wherever the shallow cover of decaying leaves and vegetation is scraped away. Generally, from 5 inches to over a foot below the surface, the clay is deep brown in colour from the admixture of decaying vegetable matter, and quite friable, and rootlets of even the smaller vegetation reach far below that level. On some of the ridges, where forest fires have been frequent, the light buff coloured clay, without any appreciable coloration from vegetable matter, comes to the surface. The rolling character of the plateau generally provides fair drainage, but over considerable areas in the central portion, which lie far from the valleys of the larger streams, there are large tracts that have not sufficient slope to ensure the proper flow of the surface water. In most cases these areas are so situated that they could be drained without much difficulty.

DESCRIPTION OF ROUTES OF TRAVEL.[1]

Except a small part of the southwest which lies in the half wooded country, the region under consideration is too densely forested to be easily accessible by cart or pack train. The rivers and lakes form the highways of travel during the season of navigation which, over most of the district, extends from early in May to late in October. Owing to the steep gradients, rapids, and falls of most of the rivers, and to the necessity, on many of the routes, of crossing by portages from one watershed to another, boats must be used that are conveniently carried or dragged overland. For light travel, the bark canoe of the Indian, or its improved form, the Cedar, basswood, or canvas-covered canoe of the white man, is best suited, since it is manageable in rapids and is easily carried on men's shoulders

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[1] Geological notes referring to these routes will be found under detailed description of rivers and lakes.

(Plate V.) For heavy transport the more strongly built and larger boat, known as the York boat, used generally by the fur brigades, is well adapted. It is propelled by sweeps or by sails on smooth water, and is poled or towed with a tracking line up the swift currents of the rivers. Where portages must be made the boat is dragged overland with the help of skids and rollers (Plate XVIII).

In the winter season snowshoes and dog-trains offer a means of travel, that though somewhat laborious, is fairly expeditious.

Saskatchewan River.

The river is navigable, except during periods of low water, by shallow draught, high power river steamers, from the head of the Grand rapids, at its mouth, to Prince Albert and beyond. Rapid current, tortuous channels between islands, and shifting sandbars make the services of a skilled pilot necessary for safe travel in the present unimproved state of the channel. Improvements, that are now under contemplation by the government, will remove many of the difficulties of navigation and make the river a fairly good water route.

The trip downstream on the river by small boat or canoe is an easy and delightful one. The continuously rapid current makes the labour of paddling light, and all the rapids may be run with ease except Grand rapids, just above Lake Winnipeg, which is passed by means of a tramway 3½ miles long, or by running part of the way and making a portage 87 chains long. The ascent of the river, on the other hand, is most laborious; the current is too strong for paddling and the water is too deep generally for poling; tracking must be resorted to for almost the whole distance between the Pas and Prince Albert. For tracking, which is the method used in ascending all swift flowing rivers in the northland, a long, light tow-rope is used; it is manned by part of the crew, one remaining aboard to guide the boat; the trackers trudging along the rough shore and climbing many obstacles, tow the boat upstream at the rate of a fast walk.

Carrot River.

Like the Saskatchewan, Carrot river is much more easily descended than ascended. From its mouth to the Red Earth Indian reserve above the Sipanok channel, it is deep and slow flowing, and may be traversed either way with ease by boat or canoe and even by small launches. From the reserve upwards it can be travelled only by canoe, and with difficulty, owing to shallow water and constantly recurring rapids.

Churchill River.

Along the portion of its course above Northern Indian lake, the Churchill takes the form of a chain of lake-like expansions, many of them of large extent and quite worthy the name of lakes, with short, connecting stretches of rapid water.

For this distance, except the 60 mile stretch between Reindeer river and Nemei river, which is rough, the river affords a good route for canoes or boats; the portages are short, and lake expansions are almost continuous, so that the river may be ascended or descended almost equally easily. Leaving Stanley, on a downstream trip, 5 miles of quiet water leads to Grave rapid, descent 4 feet, which is passed by a portage about half a chain long on an island which divides the rapid. Below the rapid the river expands into an irregular lake which extends easterly for 12 miles to Pine rapid. The lake is divided about midway by a narrow, tortuous portion with a swift current, below which Rapid river, the outlet of Lac La-Ronge, comes in from the south.

Pine rapid, where the descent is 7 feet, is passed by a portage three chains long, on the right bank, leading to Drinking lake. Island portage, 10 chains long, leads, past a rapid with a descent of 7 feet, to Keg lake which extends easterly for 8 miles, divided into several channels by long, narrow islands. From the end of the lake a crooked, river-like stretch, 2 miles in length, extends easterly, broken at the head and foot by rapids, necessitating portages of 3 chains and 26 chains, respectively. Keg rapid, the upper of the two, has a descent of 7 feet, and Grave rapid, the lower, upwards of 16 feet. Trade or Island lake, a beautiful stretch of water averaging a mile and a half in width and dotted with islands, extends easterly for 13 miles to Frog portage, where it turns abruptly to the north and continues for 5 miles past Perch brook, a large stream coming from the north, to a narrows with two short stretches of swift current. Thence northerly, an expansion known to the Indians as Manawan lake forms a long, narrow lake with Kettle fall, 17 feet high at the lower end. By a portage of 4 chains, the expansion is reached into which Reindeer river falls. The river forms the York

Reindeer river

boat and canoe route to Reindeer lake, and is thus described by Tyrrell:—

[1]‘The Reindeer river and the Churchill river above it flow in one continuous valley, which the united waters leave by what appears to be a gap in the hills to the east.’ ‘For the first 6 miles Reindeer river forms a narrow bay of Churchill river; it is then broken by a rough rapid known as Deer rapid. For the next 32 miles to Steeprock falls and portage, the river fills the bottom of a valley between hills from 200 to 400 feet in height, and has the character of a long, narrow lake rather than a river; for only in three or four places could current be detected. On both sides deep bays frequently indent the shore. Some of the hills are rugged and almost bare, though most of them are covered with forests of aspen . . . . Below Steeprock fall there is quite a heavy rapid, and at the fall the river flows in several channels between islands wooded with spruce, tumbling 15 feet over a band of gneiss. The portage is over a hill, rising 40 feet above the water at its lower end, composed entirely of light grey compact clay, apparently without boulders. In the next 18 miles, the river widens into several small lakes, and the banks rise in gentle rocky slope, the knolls of bare grey gneiss peeping out here and there through the covering of poplar woods. Between the knolls, the surface is underlain by light grey till. Then for 7 miles it flows in a regular well defined channel, winding through a low bottom-land wooded with small spruce and tamarack, behind which rise the rocky ridges.’

‘At the upper end of this well defined channel the water rushes between high, almost vertical, rocky walls, forming what are known as Manitou rapids, where canoes ascending are passed with difficulty over a low, rocky island in the middle of the stream and then paddled with all possible speed across the rushing current to an eddy in a bay on the eastern bank, failing to reach which they are engulfed in the heavy waves below.’

‘Above Manitou rapids the river opens out into a small lake with rocky shores. Passing from the southern to the northwestern angle of this lake, the stream is again encountered as it descends about 16 feet in two distinct falls on a rocky ledge . . . On the north side of the falls are cliffs about 50 feet high of orange coloured stratified sand and gravel . . . . Above Whitesand falls the river opens out into another small lake, on both sides of which are sandy terraces 15 feet above the water. Above this lakelet is a short stretch of current, at the head of which is a fall of 8 feet. Canoes reach the quiet water above it by a short portage across a bare island of grey gneiss . . . . This island is known as Rock portage, and the open water to the west of it is the southern end of Reindeer lake.’

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[1] Geol. Survey, Canada, Vol. IX, 1896, Pt. F.

On Churchill river, at the foot of the expansion into which Reindeer river falls, is Attik rapid with a descent of 15 feet. Below, the river is rather rough for 60 miles, with many bad rapids, including the long Wintego rapids at the foot of Wintego lake, Mussenakeigen, and Mukoman rapids. Ten or twelve portages are made along this stretch, the longest about half a mile in length.

From the end of the rough water stretch, at the mouth of Nemei river, to Pukkatawagan, 120 miles below, the Churchill flows for almost the whole distance through lakes, and only four short portages are necessary. Between Pukkatawagan and Southern Indian lake, a distance of about 130 miles, the lake expansions are larger, and include Granville lake, 50 miles or more in length. In this distance four short portages lead past rapids and falls, one of which, Granville fall, above Granville lake, has a nearly vertical descent of 25 feet.

The course through Southern Indian lake follows the eastern shore for about 60 miles to the outlet. Missi fall, just below the lake, has a vertical descent of 18 feet.

The portion of the river between Southern Indian lake and a point 20 miles above the mouth of the Little Churchill has not been explored. Of the 23 miles above the junction of the Little Churchill Dr. Bell says:—

'I ascended the Churchill for a distance of 23 miles (following the stream) from the mouth of the Little Churchill. In this distance it averaged about one-third of a mile in width and had high banks of clay on alternate sides. Numerous rapids were met with, and the total rise in the above distance amounted to 173 feet, or at the rate of 7½ feet per mile . . . .'

'The distance from the junction of the Little Churchill to the mouth of the river, according to my survey, is about 105 miles in a straight line . . . . A considerable stream enters from the left side at 20 miles below the Little Churchill; but with this exception the tributaries are apparently all small. For the first 25 miles, in a straight course, below the point just mentioned, the river bends about a good deal, but from thence it makes only two, nearly straight reaches to the sea. From the forks to the end of these the average width of the river is about half a mile and few islands occur, but in the last reach islands are numerous, and the width, for a considerable distance, is upwards of 2 miles. The tide extends to the foot of the last rapid, a distance of 7 or 8 miles from the open sea, the intervening section forming a lagoon about 2 miles broad. The mouth of the river, which is bounded by solid rock, is less than half a mile wide, and the point on the west side projects some distance beyond the other. The fine harbour of Churchill lies immediately within the mouth of the river.'

Three miles below the mouth of the Little Churchill, the main river is usually left and the route by way of Deer lake is followed. For the trip downstream the main river affords a good route, without portages, though with an element of danger, from the low, vertical walls of ice which form the banks for the greater part of the year.

[1]''In order to reach the head-waters of the Deer river, we left the Great Churchill 3 miles below its junction with the Little Churchill. Here we made a portage a mile and a quarter long in a due east course over a hill having an elevation of 300 feet above the river. This portage brought us to a lake half a mile in diameter with banks of peat from 3 to 7 feet in thickness overlying permanent ice.'

'From this lake another portage 90 chains in length over a peat bog was made to a lake a mile and a half long by half a mile wide. Then, by a third portage one mile long over a short and steep morainic hill 100 feet high, followed by a mossy, black spruce swamp, we reached Deer lake, the head-waters of the Deer river.'

'Deer lake runs northwest and southeast; it is 2 miles long by half a mile wide, with low banks of moss. Morainic clay hills having an elevation of 300 feet above the lake are seen 3 miles to the northward. Lower morainic hills occur all along the upper part of the Deer river for 30 miles down from Deer lake.'

'The Deer river is 110 miles in length, and runs in a northeasterly direction. It is very crooked, and its swift, shallow waters occasion many rapids, which we often had to wade with our loaded canoes.'

'The river from here down to the Great Churchill flows over limestone; numerous large fragments of limestone were seen all along, and with our paddles we could feel the solid rock in many places at about 3 feet under water.'

'As already stated, the whole country has been overrun by fire. Bunches of spruce and tamarack that escaped the fires were frequently met close to the water's edge.'

'At 62 miles down from Deer lake we came to the open, mossy plain which extends northward to the well wooded banks of the Great Churchill.'

'The distance from the mouth of the Deer river to the Hudson's Bay Company's post called New Fort Churchill is 22 miles in a northerly direction. This part of the Great Churchill is 2 miles wide with a swift current to Mosquito point. Here the river narrows to one mile, forming a short, swift rapid running into the shallow tidal lagoon at 7 miles from the mouth of the river.'

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[1] Geol. Surv., Canada, Summary Report, 1906.

'The post is situated on the west bank of the lagoon 3 miles from Mosquito point. The tide runs out for nearly a mile in front of the post, leaving a mud-flat strewn with numerous boulders, some having a diameter of 7 feet. The lagoon, when full at high water, is over 2 miles across from the Company's landing, but at low tide the river runs in a channel one mile broad, cut through sand and mud, to Churchill harbour.'

'Fort Churchill is the most southern harbour on the west coast of Hudson and James bays for ships drawing over 20 feet of water. It is nearly 2 miles long and from half a mile to three-quarters of a mile wide. Several soundings were taken and 30 feet of water was measured at low tide within 300 yards of high water mark on the west bank. Sand and gravel, with boulders, form the river bed.'

'The west bank of the lagoon and harbour, from Mosquito point to Old Fort Churchill or Prince of Wales, at the mouth of the river, is bare and rocky. Hills of quartzite rise to 100 feet above high tide. With the exception of a few square chains around Sloop cove, 3 miles up from the mouth of the river, the Hudson's Bay Company and Mission have taken nearly all the habitable ground on the west side. This consists of an old clay and sand beach about 800 yards long by 200 yards wide.'

'At a mile and a half up from Battery point, the Hudson's Bay Company have a whaling station which is situated at the foot of the rocky ridge. From this point old beaches made up of clay, sand and gravel are seen at different levels running in a southeasterly direction, the highest attaining an elevation of 50 feet above the river. This side of the lagoon had a more inviting aspect than the opposite rocky, hilly shore.'

'The route most commonly used to the lower Churchill follows Nelson river to Split lake and thence reaches the Churchill by way of the Little Churchill.'

[1]'On leaving Split lake we made a portage at the head of a bay 3 miles long by half a mile wide, lying in a northerly direction from the Hudson's Bay Company's post. This portage, which is one mile and three-quarters long, lies mostly through swamp and leads to the shore of a small lake 40 feet above the level of Split lake. We followed its outlet through a low, swampy country to Assean lake, a total distance of 2½ miles in a northerly direction. In this last there are two narrow clay ridges running east and west, having an elevation of 15 feet above the water.'

'Assean lake, which lies east and west, is about 12 miles long and has an average width of a mile. Its shores, generally rocky, mostly gneiss, are well wooded with black spruce, tamarack, and white birch. A fire that occurred two years ago ran from its southeastern end for several miles eastward.'

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[1] Idem.

'The Ouatawi river, entering Assean lake at its eastern extremity, is small and crooked. We followed it to Ouatawi lake, a distance of about 14 miles on a north course. This lake is about 3 miles long by half a mile wide. Grey granite with foliated mica schist occurs on the west shore at one mile from the outlet.'

'From this point we made five portages and crossed four lakes, the largest one a mile and a half in length, and reached a bay of Waskaiowaka lake, a total distance of about 6 miles in a straight line in a northerly course. No rock exposures were noticed in this last stretch. The country is generally low and swampy up to the last two portages, into Waskaiowaka lake (called Big lake by the natives), where hills of clay running east and west rise to 30 feet above the level of the lake.'

'The canoe route from the last portage follows the eastern shore of Waskaiowaka lake for 6 miles in a northerly direction to its outlet, called the Little Churchill.'

'Waskaiowaka lake is about 16 miles long. It has two expansions, the one on the south being about 10 miles in length by 5 miles in breadth. A short narrows connects it with the northern expansion, which is about 6 miles long by 4 wide. The rock is generally gneiss and granite; clayey hills rising to 50 or 60 feet above the level of the lake form the southern shore of the northern expansion.'

'Three miles south of the outlet, on the east shore, steep banks occur, covered with 10 feet of mossy peat. The forest growth is chiefly black spruce and white birch of from 4 to 14 inches in diameter.'

'Starting down the Little Churchill we traversed a swampy country for 4 miles. Here the river expands, forming a lake 2 miles long and one and a quarter wide. On the east side, near the outlet of this expansion, a hill of drift covered mostly with black spruce averaging 8 inches in diameter rises for 200 feet above the level of the water.'

'Three miles farther down, the Beaver river, one chain wide, comes in from the northwest, and one mile below it the first portage was made, passing to the left of a strong rapid giving a total fall of 70 feet in a distance of 23 chains.'

'For a distance of 7 miles from here down the river only two portages were made, the longest one measuring 24 chains with a total fall of 15 feet.'

'Half a mile below this last portage, a cross-section of the river, taken on July 14 when the water was at medium summer level, gave a flow of 150,000 cubic feet per minute as the mean volume.'

'Six miles of swift current from this point brought us to comparatively still water, the river again spreading out and forming many expansions and islands, until Recluse lake (called Waskaiowaka by the natives) was reached, a total distance of 45 miles from Waskaiowaka lake.'

'The country on both sides of the Little Churchill so far, is generally rocky or swampy, with black spruce, white birch, and tamarack of small size. At the forty-second mile, the Switching river comes in from the west. This river has an approximate volume of 75,000 cubic feet per minute.'

'Beds of peat of from 2 to 8 feet in thickness, overlying permanent ice, were noticed at several places in this last stretch.'

'On entering the Recluse lakes the east shore follows an expansion a mile and a half long by a mile and a quarter wide; then occurs a narrows a mile and a quarter long, leading to the northern part of the lake which runs east and west for 4 miles and has an average breadth of 30 chains. At the narrows the Hudson's Bay Company maintains a winter station, supplied by the Split Lake post.'

'From the forty-seventh mile, at the outlet of Recluse lake, we made two short portages and ran a strong rapid, giving a total fall of 20 feet in a distance of half a mile. The last portage on the Little Churchill was made at a point two and a half miles below this rapid. From here the general course of the river, which is nearly due north, keeps a uniform width of about three chains with a swift smooth current to its junction with the Great Churchill, a total distance of 126 miles from Waskaiowaka lake.'

'Gneiss and granite are seen in many places, particularly at the portages on the upper part of the river. There were no rock exposures seen below the last portage.

'At 80 miles down a good view of the country was obtained from the top of a clay hill, 75 feet above the river. From this hill the Little Churchill could be seen running through a valley about 6 miles wide to the foot of morainic clay hills which rise to 300 feet above the river.

'From this point northward the country, which has been overrun by a fire that occurred forty years ago, is now partly covered with bunches of second growth black spruce, tamarack, and white birch.'

Prince Albert to Churchill River.

A wagon road, 80 miles long, leads from Prince Albert northerly to Montreal lake. For the first 30 miles after leaving the Saskatchewan the road is in fairly good order; it follows gradually rising, dry ground to near the head-waters of Little Red river, passing on the way through fairly good land with light soil, alternating with broad bands of almost pure sand. For the rest of the distance to Montreal lake the road is rough, and crosses a number of long muskegs that make it almost impassable in periods of wet weather. Montreal lake is about 28 miles long by 4 miles wide. It has an elevation of 1,600 feet or more above the sea, and is surrounded by hills that rise to elevations of about 2,000 feet. The river, except at periods of low water, forms a fairly easy canoe route, since, though it is broken by many rapids, they can all be run going down, or poled coming up, except two, one passed by Montreal portage, 2½ miles long, and another by High portage, 10 chains long. The river flows into Lac LaRonge, from which there are two principal connexions with the Churchill, one by the four portage route to Stanley and another by the outlet, Rapid river, which falls into the Churchill 8 miles below Stanley. On Rapid river two rapids are passed by portaging, the lower one, near the Churchill, having a descent of 51 feet with one vertical pitch of 30 feet (Plate V).

Route from Cumberland Lake to the Churchill.

For more than a century the route by the Saskatchewan to Cumberland and thence by Sturgeon-weir river to the Churchill gave access to the northern interior and to the Mackenzie basin. By it goods for the fur trade were brought in and return cargoes of furs were carried out. Although the strength of the current makes poling and tracking necessary for a part of the way and also occasional portages, the route on the whole is an easy one and is used by York boats as well as canoes.

From the Saskatchewan the route traverses Cumberland lake and its northeast extension, Namew lake, and follows Sturgeon-weir river northward. The lower part of the river, to just below where Goose river falls in from the east, is swift flowing and is passed on the upward trip by poling. The first rapid is met with half a mile above the mouth of Goose river, where a portage is made over flat limestone ledges. From this point to Amisk lake, the river flows, generally with a swift current, between banks of clay and silt from 10 to 15 feet high, but falling away to low land behind. At a few of the rapids on this portion of the river portages are necessary, but most of them may be ascended by tracking or poling.

Along the southwest shore of Amisk lake, which is followed to the inlet, are almost continuous exposures of flat-lying or gently undulating, heavy-bedded, magnesian limestone, underlain by thin-bedded dolomites. The disintegration of the lower, thin-bedded strata causes the formation of cliffs that rise, two or three chains back from the shore, to heights of from 20 to 40 feet. These are, in many places, flanked by outstanding, detached, tower-like masses, while the intervening space is covered by a very rough talus of large, angular blocks from the cliff face.

The cliff continues in a northerly direction up Sturgeon-weir river, forming the south side of the valley as far as Spruce portage, 3 miles above the lake, while black and white biotite gneisses are exposed, at intervals, in low rounded ledges in the bed of the stream. To Spruce portage and for a few miles beyond, the banks are low and the river winds through a low valley-bottom. Rocky ridges form the banks of a stretch of quiet water extending to Scoop portage, where the stream falls over smooth ledges of gneiss. Long stretches of deep water and moderate current continue to the foot of Mirond lake, broken at intervals by rapids which are passed by Leaf, Birch, Island, and Corneille portages. Traversing Mirond lake, Pelican Narrows post and mission, situated on the north shore, are passed at 12 miles and the head of the lake reached 7 miles beyond. Three portages follow in rapid succession and Woody lake is reached, which receives at its head the overflow of the Churchill, with which it is connected by Frog portage.

Grassberry River Route.

An alternative route from Cumberland lake to Pelican narrows follows Grassberry river, a tributary entering Cumberland lake at the northwest end.

From the Saskatchewan, the route follows the narrow, winding channel of deep water which forms the only navigable portion of the western part of Cumberland lake. For 20 miles Grassberry river is a shallow stream, flowing for long distances with swift current over flat-lying ledges of limestone. The banks are of friable clay that seems to constitute a good soil. Windy lake, the first expansion, is connected with Suggi lake above by a short stretch of swift, shallow river. Both lakes have the smooth outlines that generally characterize lakes lying in the limestone area. Ten miles of swift, shallow water, broken by many rapids, intervene between Suggi and Acheninni lakes; and similar short stretches of river connect Acheninni with Bigstone lake and Bigstone with Limestone lake, from which Deschambault lake is reached by a long portage.

Deschambault lake, a body of water upwards of 50 miles in length, is made up of a northern portion, lying within the Pre-

Cambrian area, of most irregular outline and dotted with islands, and a southern portion, situated in the limestone and drift covered area, that is characterized by rounded outlines and a large expanse of open water unbroken by islands. Wapawekka river, a shallow, rapid stream draining Wapawekka lake, falls into the northwest bay of the lake. From Deschambault lake one short portage leads to Mirond lake and Pelican narrows.

Kississing River Route.

The Churchill is reached from Cumberland by another route branching from Sturgeon-weir river at Goose river, and following Goose and Athapapuskow river and Pineroot river to Kississing lake and river. Though somewhat shorter than the others as a route to the lower part of the Churchill, the shallowness of the water in the rivers traversed and the great number of portages necessary, make it less desirable even for lightly loaded canoes.

Routes to Reed Lake and Grass River.

Reed lake is most easily reached from Cumberland by way of Goose river and lake and the Cranberry Lake route. Although it is necessary to make one long portage leading to Cranberry lake and to pass a number of rapids on the rivers traversed, this route is not a bad one for canoes. A shorter but more difficult route leaves the Saskatchewan opposite the Pas by a good road 13 miles long leading to Atikameg lake, from which a short portage leads to Cormorant lake. From Cormorant lake, the inlet, Cowan river, is followed to its head. The stream, in its lower part fairly large, becomes gradually smaller and eventually is lost in a broad swamp which must be crossed to Reed lake.

[1] Burntwood and Grass Rivers.

Good canoe routes through the section of country lying between Churchill and Saskatchewan rivers are afforded by Burntwood and Grass rivers.

The first drains Burntwood lake, from which Nelson lake on the Churchill may be reached by a portage from its northwestern end. From Reed lake an easy canoe route leads to Burntwood lake by the way of File lake, which is reached by a 3 mile portage, and File river. Burntwood river, which is more fully described elsewhere in this report, is a stream of large volume, and is used as a York boat route from Split lake to Nelson House in west longitude 99°, and, although rapid and broken by many falls and rapids which necessitate portages, may be navigated by canoes to its head.

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[1] For geological notes see detailed description of rivers and lakes.

Grass river flows from Reed lake as a river of considerable size. To the first expansion, a distance of 6 miles, the current is generally swift and in places rapid; two portages are made past falls of 10 and 5 feet respectively. Ten miles of quiet water, where the river has the character of a long, narrow, rock-bound lake, lead to a river-like portion where the current is strong, terminating in a rapid, down which the river descends 48 feet to Wekusko lake: a broad expanse of moderately clear water with bold, rocky shores, which at its southern end touches the base of the high escarpment; marking the northern edge of the belt of Ordovician limestone. Below the lake for nearly 20 miles the river has again the character of a narrow lake, with high, rocky shores and an almost straight course. Just below the end of this lake-like portion, three heavy rapids occur where a belt of schists crosses the valley.

[1]'Below these rapids the banks for a mile and a half are formed of a more or less open terrace from 10 to 15 feet above the water. Then the river turns sharply and flows for 5 miles southward on the east side of a high ridge of dark green schist, probably altered diabase. From the foot of the ridge it swings round again in an easy curve towards the northeast, passing some hills of dark green, highly altered diabase which rise in the middle of a wooded valley.'

'At or near these hills the river . . . . . enters a country of lower surface contour, underlain by Laurentian granites and gneiss, though these rocks are usually hidden by stratified Lake Agassiz clays. From the bend the river winds between low reedy clay banks for 7 miles to a series of three rapids with descents of 12, 15, and 8 feet, respectively, over grey or reddish gneiss . . . . The second and third of these rapids are known to the Indians as Kanisota (or the Two) rapids.'

'For 10 miles below Kanisota rapids, the river has a gentle current and flows between sloping banks of light grey clay, wooded with white and black spruce and Banksian pine. The surrounding country seemed to be a level clay plain, more or less completely covered with swamp.'

'At Wapikwachew (or White Forest) rapid is a barrier of medium grained, light grey, garnetiferous granite, and a similar, though lighter coloured granite again outcrops at Stickago (Skunk) rapid, three miles and a half farther down the stream . . . . A mile and a half down stream is Wapichtigow (Whitewood) falls, one of the highest on the river, where the water tumbles 40 feet over a ridge of evenly foliated dark grey hornblende gneiss . . . . .'

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[1] Geol. Surv., Canada, Annual Report, Vol. XIII, 1890, Pt. F.

'For 3 miles farther to the mouth of Metishto river, the river continues to flow with decreasing current which is interrupted by two slight rapids over reddish or grey gneiss. Metishto (Sweat tent) river is stated to rise within a short distance of the northwest arm of Moose lake, and to flow northward with a gentle current to within a few miles of Wekusko lake, below which it is a narrow, rapid stream difficult to navigate with canoes. From here to Setting lake, Grass river is wide and currentless, with greenish milky water. A short distance below the mouth of Metishto river it crosses the end of Metishto lake, which has rocky shores, and then it continues north-northeastward for 7 miles in a straight valley a quarter of a mile wide between wooded ridges of gneiss, the banks of the channel being everywhere low and marshy. It then turns eastward and cuts across the north end of Pakwahigan lake . . . . .'

'Setting lake, or as it is locally known, John Scotts lake, is a long and comparatively narrow body of light-brownish water, extending in a northeasterly and southwesterly direction. Its southwestern end was not examined. The widest portion of its northern end is divided longitudinally by a chain of gneissic islands. The shores are for the most part composed of a beach of smooth grey gneiss striking with the long axis of the lake, overlain by a few feet of clay, which is wooded with a forest of small poplar or spruce and larch, much of which has been destroyed by fire.'

'Grass river flows out of the northeast end of Setting lake over Sasagiu (or Golden Eagle) rapid, which has a descent of 12 feet. The rock is a reddish-grey gneiss, striking N. 15° E. and dipping N. 75° W. at an angle of 30°. Below this rapid the river opens into another small lake 4 miles long, the western shore of which is composed of vertical, thinly foliated, dark-grey hornblende gneiss, interfoliated with bands of medium-grained white granite. At the foot of the lake is Pisew or Lynx falls, with a descent of 50 feet, first over an abrupt fall and afterwards down a steep, broken rapid in a narrow rocky channel.'

'Below Pisew falls the river flows in a very direct course north-northeastward for 23 miles to the south end of Paint or Manuminan lake, though for most of the distance it is without appreciable current. Generally speaking, it follows the strike of the gneiss, except at the rapids where it crosses ridges of gneiss. Its banks usually rise in gently rounded slopes to heights of about 100 feet, and consist of rocky ridges of gneiss covered with a thin coating of soft brownish clay without pebbles or boulders. The summits and sides of these hills are generally wooded with small poplar, but through the poplar and down close to the bank of the stream are some scattered groves of large white spruce.'

From Paint lake a route leads through Wintering lake and Landing lake to the foot of Sipiwesk lake on Nelson river. Below Paint lake, for 50 miles to its mouth at the Grand rapids of Nelson river, the river forms, for the greater part of the distance, a chain of straggling, irregular lakes, connected by narrow river-like stretches with more or less current and occasional rapids.

Nelson River Route.[1]

Flowing from the north end of Lake Winnipeg, the Nelson expands a few miles below, to form Playgreen lake, from which it flows by two main branches made up of many channels. For the first 100 miles of its course, to the foot of Sipiwesk lake, the river retains this divided character; from Sipiwesk lake it flows in a single channel.

Leaving Lake Winnipeg there is deep water navigation, on the West branch, to the north end of Playgreen lake, a distance of about 60 miles; and on the East branch to Sea-river fall, a distance of 40 miles. Other unbroken stretches of deep water occur along the course of the river; one extends the whole length of Cross lake; another from the head of Sipiwesk lake to Grand rapids; and another from the foot of Grand rapids to below Split lake. The East branch is mainly used as a canoe and boat route to Cross and Split lakes, and the country tributary to them, though the upper portion, to a point 9 miles below Sea-river falls, forms part of the main route, via the Hayes river, to Hudson bay. The chute at Sea-river fall (Plate XI) is generally run by loaded boats, but it is necessary to unload and track them up the current. Below the fall for 6 miles the river is dotted with small islands, and becomes gradually wider to the High Rock, where the channel followed by the Hayes River route branches off to the right. From High Rock to Pipestone lake the river flows in a number of deep, canal-like channels between rocky islands, the current is generally strong and in places rapids and falls occur; past three of these portages are necessary. From the head of Pipestone lake to where the river flows from Cross lake, navigation is unobstructed. An intricate network of channels connects Cross and Sipiwesk lakes. The current through these channels is swift, and portages past rapids and falls are made at Ebb-and-Flow rapid, Whitemud fall, Bladder rapid, and Chain of

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[1] For geological notes see detailed description of rivers and lakes.

Rocks rapid. For the next 105 miles, through Sipiwesk lake and down the stretch of deep water extending to Grand rapids, though the current is strong and even rapid in places, no portages are made. At Grand rapids a portage of 9 chains is necessary, but the next little rapid, at the entrance to Split lake, may be run by canoes or boats. From Split lake to the head of navigation, the river descends 470 feet in a distance of about 115 miles; the rapids are numerous and rough and necessitate many portages. Birthday rapids are passed between Split lake and Gull lake, and Gull rapids just below Gull lake. Kettle rapids and Long Spruce rapids follow, below which are the two Limestone rapids, the lower one marking the extreme head of navigation from Hudson bay.

Hayes River Route.[1]

The Hayes River route, from the days of the first explorers, has been the avenue of communication between the northern part of Hudson bay and the interior. By it the Hudson's Bay Company brought from the bay annually the great quantity of goods used for the fur trade of the whole interior country, and it is still used for the more limited communication that is maintained between Lake Winnipeg and the bay.

Leaving Lake Winnipeg, the travelled boat-route to York Factory on Hudson bay follows the Nelson river to High Rock, below Sea-river falls, where it diverges and continues by a series of lakes and streams lying to the east of the Nelson. The distance is about 300 miles and the total descent from Lake Winnipeg about 710 feet.

[2]"Notwithstanding this considerable amount of fall, in going from Norway House to York Factory, the difficulties of boat navigation in descending are not great, but are more serious in returning. In the downward journey it is necessary to haul the boat over dry ground only three times, namely, at the watershed of the Echimamish, the Robinson portage, and the Trout fall. These portages measure 28, 1315, and 24 yards, respectively. All the other rapids are run by York boats, and mostly with a full cargo, but at some of them more or less of the load requires to be carried past by land. In the upward journey there are in all about twenty demi-charges, or hauling places, and in addition to the three complete portages which require to be made in going down, there is a fourth, the Island portage, about 40 yards in length.

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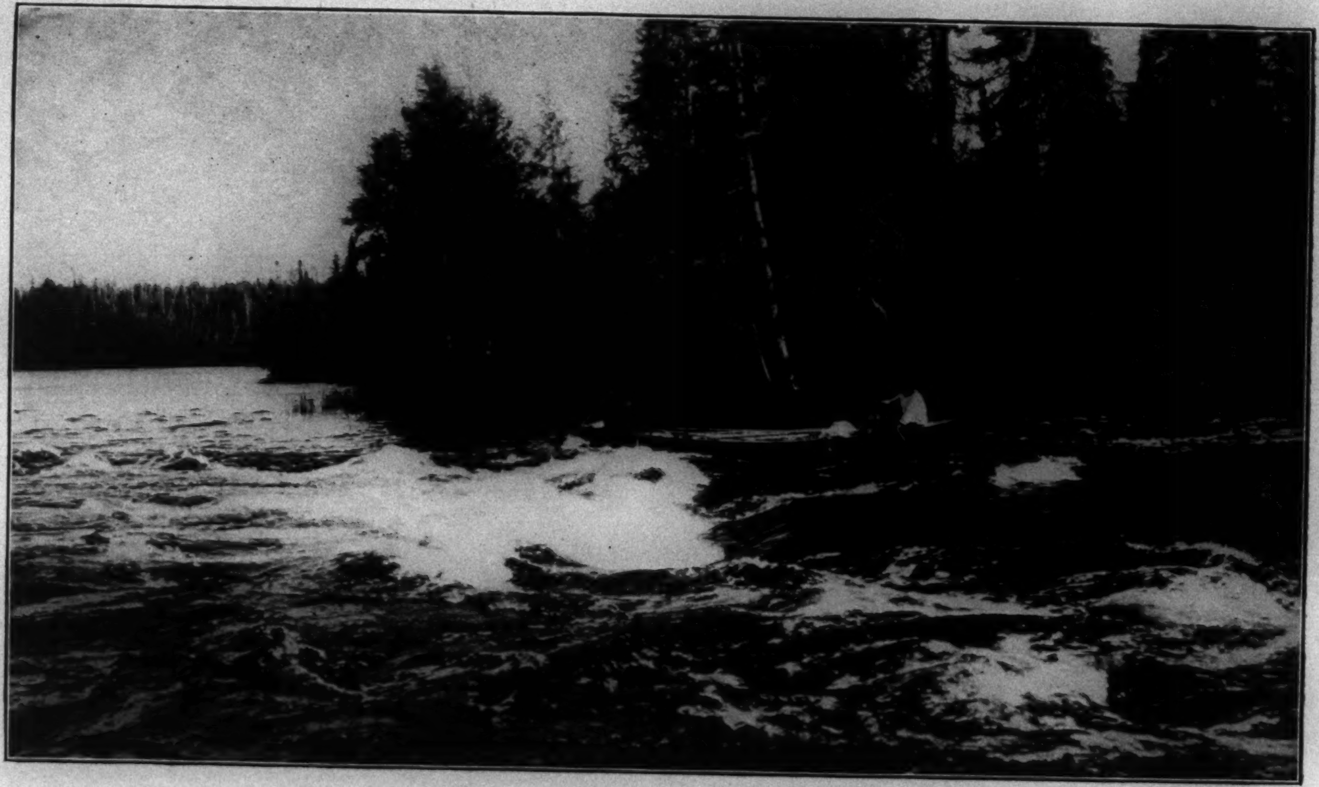
[1] For a description of the rocks occurring along the route see detailed description of rivers and lakes.

[2] Geol. Survey, Canada, Report of Progress 1877-78, Pt. CC.

PLATE VI.



Running rapid below Oxford House, Hayes river.

Photo by R. W. Brock, 1910.

PLATE VII.

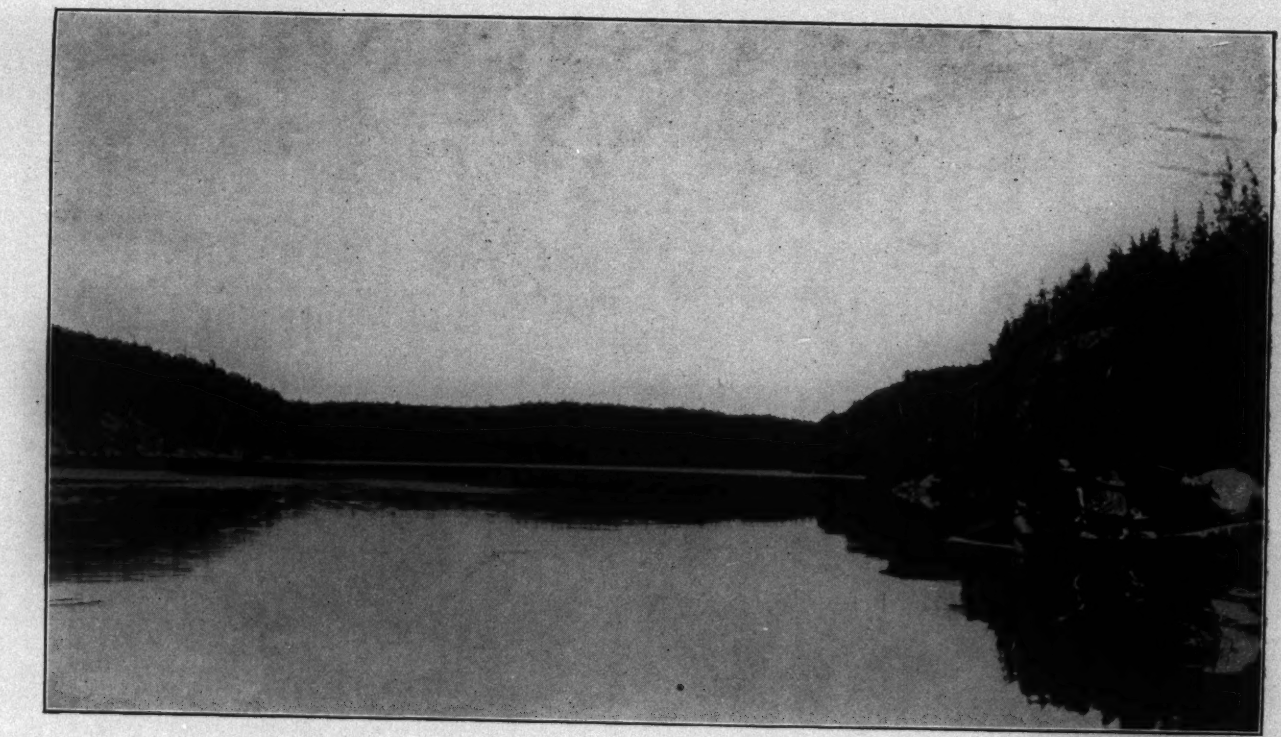


Photo by R. W. Brock, 1910.

Hayes river, below Painted Rock portage.

'The boat-route leaves the east channel of the Nelson river 25 miles below Norway House, and turns up a small, swampy, and marshy stream called Echimamish. In the interval the river is full of islands, and would average about a mile in width, including them. The shores are rather low, but not often swampy. The banks consist of a light coloured clay, with gneiss frequently appearing underneath it, and forming the points and smaller islands. The timber consists of spruce, tamarack, Banksian pine, white birch, aspen, balm of Gilead, and willows, with a little balsam fir.' . . . .

'The Cree word "Echimamish" signifies a channel in which the water flows each way. Its course is eastward, and at 28 miles in a straight line from the east channel, there is an abrupt termination of the western part, at a low rock called the Painted Stone, 28 yards in width, which forms the watershed of the channel (see Plate VII). Hairy lake and two dams, with a rise of about one foot at each, are passed in the above interval. The boats are unloaded and hauled over the little watershed, and launched into what is regarded as a continuation of the same channel. The Whitewater river, which discharges Little Lake Winnipeg, joins the eastern Echimamish on the south side, at 7 miles from the watershed.' . . . .

'Around Rainy lake, and on either side of the valley of the Echimamish, low domes of rock occur occasionally near the route, and ridges which appear to rise to a height of 70 or 80 feet are seen in some places at a distance of 2 or 3 miles back. . . . . The river flows successively through Robinson, Pine, and Windy lakes. Robinson portage, the most formidable one on the whole route, occurs at the foot of the lake of the same name. The carrying-trail, which is as wide and smooth as a good wagon road, passes over the light grey clay soil which prevails everywhere in this part of the country. The descent in the river, between the extremities of the trail, was ascertained by the aneroid barometer to be 45 feet.'

'A swampy lake, without any name, extends for some miles eastward from the foot of Robinson portage. Seven miles below this portage the river enters a narrow and nearly straight ravine, with walls of gneiss from 30 to 70 feet high, through which it flows for a distance of 7 miles to Pine lake, two rapids occurring in the interval. The south side of Pine lake is bordered by small hills, but to the northeastward a low tract extends all the way to Windy lake, around which the country has a slightly undulating aspect. From this lake the river runs northwest, or at right angles to its usual course, and at the end of 4 miles falls into the head of a marsh on the level of Oxford lake. Here there is a chute called Wapinaipinis, or the Angling Place, with a descent of about 6 feet. The marsh referred to opens by a narrow strait into the southwestern arm of Oxford lake.'

'Oxford lake runs northeast and southwest, and has a length of about 30 miles, with a maximum breadth of 8 or 9 miles. It contains many islands, and is much subdivided by long points . . . . . .

Oxford House, a post of the Hudson's Bay Company, is situated on a rising peninsula formed of light grey clay, at the northeastern extremity of the lake. This lake is also called Holey lake, or, more properly, Deep-hole lake, from a small conical hole on the north side, one mile west of Oxford House, which, according to the Indian belief, has no bottom, but is in reality only 60 feet deep. The extension of the lake beyond Oxford House is called Back lake.'

'From Back lake the water passes southeast, to the head of Knee lake—the distance, in a straight line, being 11 miles.

'Knee lake has a total length of 40 miles. It consists of two principal expansions, each running northeast and southwest, connected together about midway between the inlet and outlet by a narrower portion, about 9 miles in length, running north and south. The lower part is the widest, and has a maximum breadth of about 6 miles. The whole lake is studded with islands, but they are particularly numerous in the central part, which is a closely-crowded archipelago . . . . A few small hills are seen at the head of the lake and at some other localities near its shores, but with these exceptions, the country presents all around a low and horizontal outline. The soil consists principally of light grey clay and brown, gravelly loam, but near the lake, on the northwest side of the lower expansion, much of it is sandy. Wolverine river, which forms part of the canoe route to Gods lake, enters the northeastern extremity of the upper expansion.' . . . . .

'Knee lake discharges at its northeast extremity into Swampy lake. The connecting river runs northeastward, and has a length of 10 miles in a straight line. It has a considerable descent in the lower half of its course. . . . . .

'Swampy lake is a narrow strip of water 10 miles long, and has the same northeast course as the river above and below it. Its name is derived from a point composed of peat on the northwest side, about half-way down. The surrounding country is low, but not apparently swampy. This is the last lake on the route.'

'From Swampy lake to York Factory the river curves regularly round from a northeasterly to a nearly northerly course. . . . . .

'Leaving Swampy lake, the river, for 19 miles, flows through a labyrinth of small islands. Although the banks are low, there is a very considerable and tolerably regular descent in this distance, the river being broken by a great number of rapids, all of which, however, may be run by boats. The bed of the river, and the innumerable small islands, are mostly formed of angular blocks and fragments of gneiss. . . . . At the end of the stretch so full of islands, clay banks first make their appearance on both sides, and continue all the way to the sea.'

'From Brassey hill few islands occur in the river, which has an average width of only about two chains. Several rapids and chutes over ledges of gneiss underlying the clay occur in the first 13 miles below Brassey hill. The last one, at the end of the above distance,

PLATE VIII.

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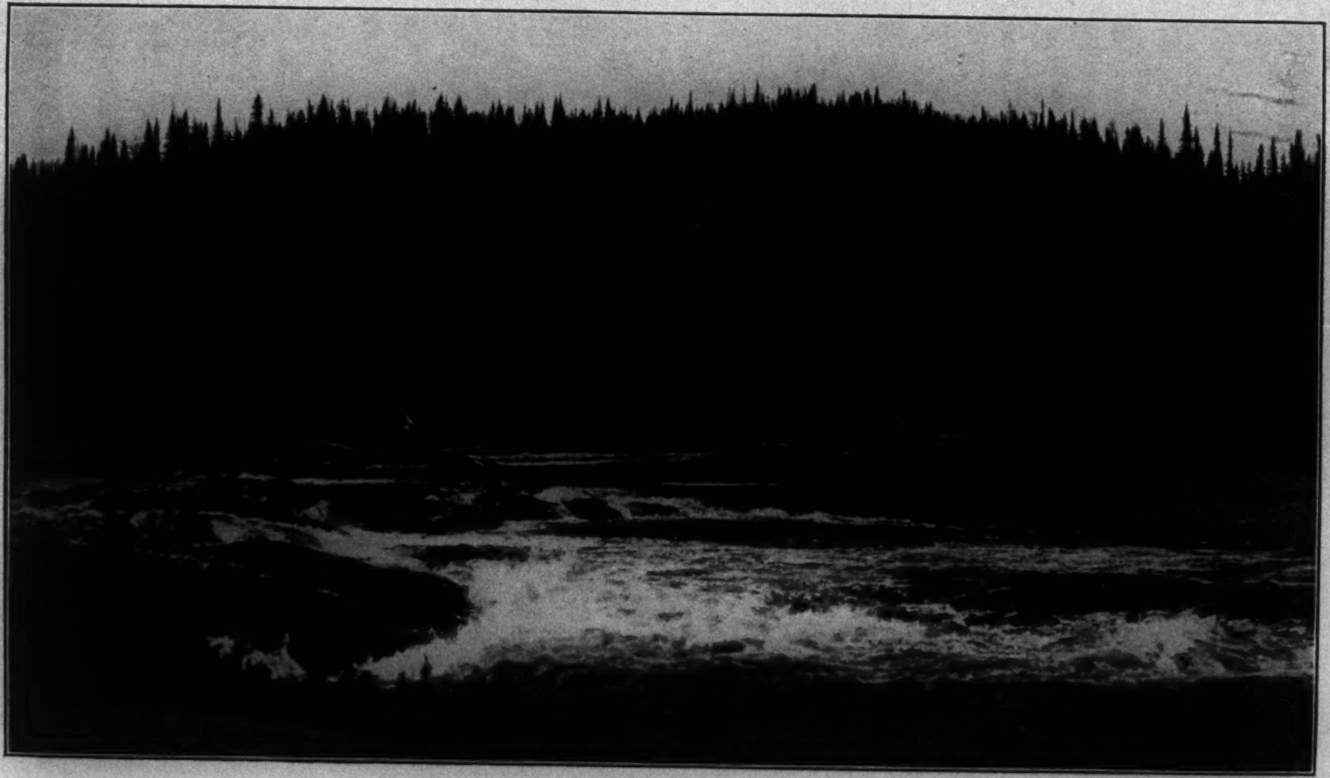

Photo by R. W. Brock, 1910.

Rapid above the Rock, Hayes river.

or 109 miles above York Factory, is called The Rock, from a considerable exposure here of dark grey, rather coarse gneiss' (Plate VIII).

'The character of the river changes at The Rock; and from that point downward no more rapids occur all the way to the sea. The stream is shallow at low water and runs with a swift current to the head of tide-water, about 9 miles above York Factory. The gravelly or sandy beach which is exposed during the summer nearly all along between the foot of the clay banks and the water, affords good walking for the men employed in tracking loaded boats upstream.'

'Clay banks, with an average height of 70 feet, are continuous on both sides of the river along this portion of its course. Marine shells, chiefly *Saxicava rugosa*, derived from the upper beds, were noticed all along this section of the river.'

'The Shamattawa appears to be a larger stream than the Hayes river with which it unites. . . . . The river has an average width of about 10 chains as far as the "Penneygutway," a small stream from the left, 24 miles above York Factory. Below this, the width is one-quarter of a mile, but increases regularly to half a mile, and opposite York Factory it has become one mile. About a mile above "Penneygutway" the river gives off a channel on the right, which is of considerable size during floods, but is nearly dry at low water. It merges again about 3 miles above York Factory, and is here called Ten-shilling creek. In descending Hayes river, the clay banks diminish in height from an average of 50 feet at the Shamattawa to 27 feet at York Factory.'

'Along the stream above described, from The Rock downward, islands are almost entirely absent, until the head of tide-water is reached. Here three wooded islands occur in succession, and below them is a chain of low islands near the southeast side, covered with grass, and affording abundance of hay for the cattle kept at York Factory.'

Nearly every part of the region covered by the map may be reached by canoe, though in the case of portions traversed only by the smaller streams, travel is necessarily slow and difficult, owing to the shallowness of the water and the number and length of the portages.

GENERAL GEOLOGY.

Geologically the region is underlain by a central complex of rocks of early Pre-Cambrian age, which has been reduced by an exceedingly long period of erosion to the condition of a peneplain. Overlapping this central complex are three separate developments of sedimentary beds, ranging in age from, probably, upper Huronian to upper Cretaceous. In the northwestern corner flat-lying sandstones, known as the Athabaska sandstones and considered to be of upper Huronian age, overlie the Pre-Cambrian; encroaching on the old rocks, from the Hudson Bay basin, to the northeast, are Palæozoic sediments ranging in age from Ordovician to Silurian; and, to the south, the ancient complex is overlain by successively newer beds, which include Ordovician magnesian limestones, Silurian magnesian limestones, Devonian limestones, and Cretaceous sandstones and shales.

Table of Formations.

Post Tertiary and Recent.		Recent alluvium, marine clays, lacustrine clays, boulder clays.
Cretaceous.	*Niobrara*............	Grey calcareous shales; oil-bearing and containing, among other marine fossils, *Ostrea congesta* and *Inoceramus problematicus*, the remains of fishes, probably *Enchodus shumardi* and many *Foraminifera;* with bands of limestone and overlaid by interbanded clay iron-stone and shale.
	Benton...................	Dark grey shales.
	Dakota....................	Loosely coherent white, quartz sands and sandstones with seams of lignite; quartzose sandstone with pyritous nodules and hard, purple, ripple-marked sandstone and conglomerate, containing carbonaceous matter probably representing carbonized impressions of comminuted vegetable matter.
Devonian.	(*Middle*).................	Buff coloured magnesian limestone, sandstone, and conglomerate; containing *Atrypa reticularis* and crinoid stems.
Silurian.	*Niagara*..................	Light yellow-buff coloured magnesian limestones, weathering white or very nearly so. Fossiliferous. A list of the principal forms is given elsewhere in the report.
Ordovician.	*Galena-Trenton*.........	Thick-bedded dark buff magnesian limestones and thin-bedded, lighter coloured fine grained magnesian limestones underlain by red magnesian limestone, and coarse white and red sandstone.
Pre-Cambrian	*Athabaska- Sandstone*....	White and dull red, coarsely granular, siliceous sandstone and conglomerate, in thick, horizontal beds.

Plate IX.

Namew lake, in the limestone area, north of the Saskatchewan river.

Photo by W. McInnes, 1910.

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Table of Formations—*Continued.*

Post Tertiary and Recent.		Recent alluvium, marine clays, lacustrine clays, boulder clays.
Pre-Cambrian *—Continued.*	*Laurentian*	Biotite granite gneiss, hornblende gneiss, amphibolite, granodiorite, etc.
	Grenville (?) (*Lac LaRonge series*)	Quartz diorites, pyroxenites, amphibolites, quartz-diorite gneisses and schists and crystalline limestones.
	Keewatin	Chloritic and hornblende schists, diorites, hornblendites, serpentine, etc.
	Igneous	Granites, pegmatite dykes, diorite dykes.

Igneous.

Under Igneous are included granites which are considered to be newer than Laurentian, as well as many dykes that cannot be separated in the mapping. Certain diorite or diabase dykes seem also to be later than the Laurentian, possibly upper Huronian or Keweenawan.

Pre-Cambrian.

A very large part of the area under consideration is underlain by a complex of old Pre-Cambrian rocks, most of which have the lithological characters and associations of the Laurentian which covers so large a portion of northern Canada. Included in the Pre-Cambrian complex, however, are rocks which from their lithological character and general aspect and composition seem to correspond to the Grenville series of eastern Canada; others which correspond in like manner with the Keewatin of the east, and others, involved with the Keewatin in the general folding, which seem to be lower or middle Huronian.

In addition to the series above referred to, all of which have been very intricately folded and which form one complex of rocks, a series of flat-lying sandstones, which occupy a broad basin to the south and east of Lake Athabaska, are considered, for reasons that are given in subsequent pages, where these rocks are described under the heading, Athabaska sandstone, to be referable to the Pre-Cambrian and to about the horizon of the upper Huronian.

Grenville (?).

A series of rocks exposed on the shores of Lac LaRonge and in its neighbourhood have certain distinctive characteristics which serve to differentiate them from the granitoid gneisses which make up the broad expanse of the Pre-Cambrian; and which also serve to correlate them with the Grenville series of eastern Canada. The rocks of the series are all intensely metamorphosed; the principal rocks represented are sheared and schistose granodiorites or gneissic and schistose quartz diorites; massive and schistose pyroxenites; hornblende schists; crystalline limestones and a metamorphic calciferous rock which in many ways resembles a sediment; the whole occurring in a series of sharp folds with a general north and south trend, but over areas of considerable size lying in a nearly horizontal, gently undulating attitude. Infolded with the rocks that resemble so closely those of the Grenville, are coarse and fine gneisses with quite the general aspect of the gneisses that have come to be recognized generally as Laurentian.

Lac LaRonge and Adjoining Regions.

Occupying most of the shores of Lac LaRonge and its numerous islands, is the series of rocks above referred to, that from their lithological characters seem to be differentiated from the gneisses of the broad expanse of the Pre-Cambrian which has been classified as Laurentian. In the Summary Report for 1909 these rocks were briefly described under the name, Lac LaRonge series, and their similarity to the Grenville series of the east was pointed out. The rocks are principally quartz-diorite gneisses and schists and hornblende schists, with smaller areas and bosses of pyroxenite, hornblende diorite and serpentine, and with one band several chains wide which can be followed for upwards of 10 miles, consisting of crystalline, magnesian limestone with conformably underlying it, an impure phase of the limestone, made up mostly of calcite but with rounded grains of quartz and feldspar, as well as some pyroxene, scapolite, and sphene. It has the appearance of having been, originally, a sedimentary rock.

To the west of the lake, on Nemeiben river, a large boss of coarsely crystalline pyroxenite forms a prominent ridge, rising from low land. The rock consists mainly of augite diallage and accessory feldspar and pyrite. Along a shear zone, occurring near the east side of the ridge, it is quite schistose in structure and is, in places, highly impregnated with sulphides, principally iron pyrite but partly chalcopyrite. A somewhat similar boss forms a small island in the lake south of Moose point. In this case, small veins of asbestos occur in it. The rocks strike about N. 20° E. and dip generally, except on the east shore where the direction is the reverse, westerly at angles ranging from 30° to vertical. They probably occur in a series of overturned folds, along the axes of which occur belts which are quite highly mineralized. Along these zones, in 1908 and 1909, many mining claims were staked by prospectors who believed or hoped that they were gold-bearing. Assays of material from nearly all the belts were made, and in no case was the gold content found to be more than a trace.[1]

The zones consist of quartz-feldspar schists, many of them mineralized with pyrite and a little chalcopyrite, and all highly altered and showing calcite, epidote, and a variety of minerals that are the products of alteration. Mostly the schists seem to have been derived from rocks having originally the composition of quartz-diorites. Except in the case of the crystalline limestone and the calciferous, metamorphic rock underlying it, there does not seem, in the thin sections examined, to be anything to strongly indicate that the rocks were originally sediments. All are, however, so much altered, that the evidence on this point is of little value either way.

Keewatin.

Many small areas of rock that, from their lithological character and relationship to the granite gneisses, are considered to be referable to the Keewatin, occur throughout the area mapped. A number of these areas are situated at the southern edge of the Pre-Cambrian area where it is overlapped by Palæozoic sediments. They are roughly triangular in shape, the base of the triangle being formed by the edge of the overlying sediments and the apex by the tapering end of the belt which fades into the gneisses. The shapes of the areas are such as to make it seem probable that they are tongues extending northward from larger areas or perhaps from a continuous area of these rocks, concealed beneath the flat-lying sediments and protected by them, from the denudation that, during much of the time that has elapsed since their deposition, was active in the northern area.

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[1] Summary Report, Geol. Surv., 1908, pp. 90 and 92.
[2] Summary Report, Geol. Surv., 1909, pp. 155 and 156.

Enumerated in order of their occurrence, from west to east, the areas that are considered to be referable to the Keewatin are: a narrow belt, extending easterly from the south shore of Wapawekka lake; an area 50 miles wide which appears from beneath the limestone cover at Amisk, Athapapuskow, and Cranberry lakes; similar areas at Reed and Wekusko lakes; one crossing Grass river below Wekusko lake; a small area at Pipe lake, Burntwood river; an area of very irregular outline at Cross lake on Nelson river, which is probably continuous with a more extensive belt crossing Oxford and Knee lakes; and, in the southeast corner of the district mapped, a number of small tracts about Gods lake and Island lake and a long, narrow belt, which has been traced for upwards of 100 miles along the upper courses of Severn river.

The belt on Wapawekka lake is a little less than 4 miles wide and trends east and west. To the south it is overlapped, in its western part, by the flat-lying sandstones of the Cretaceous, and in its eastern part is cut off by a bright red intrusive rock, which has the composition of a quartz-diorite, the bulk of the rock being composed of plagioclase feldspar, quartz being abundant and biotite occurring in quantity amounting to about 10 per cent of the whole. The rock has the aspect of a granite.

The rocks of the belt are mainly massive dark, greenish-black quartz-diorites, sheared in places to form schists; hornblendites, hornblende schists, and quartz-diorite schists and fine gneisses. Along the south shore of the narrows a very highly altered rock, which is used by the Indians for the manufacture of pipes, crops out in low cliffs. In appearance it is a soft, light coloured, greenish-grey rock dotted with small, bright red spots. It seems to have consisted, originally, almost entirely of hornblende, with accessory feldspar and magnetite, but is now strongly chloritized. To the north, it is difficult to fix the edge of the belt. Quartz-diorite schists and schistose rocks having the appearance of dacites are interbanded with fine gneisses, the gneissic structure in the rocks giving place, apparently somewhat gradually, to a granitoid structure until the gneisses assume the appearance of so-called Laurentian gneisses.

The Amisk Lake belt, where the rocks are exposed about the shores of that lake, is made up of various forms of schists that are characteristic of the Keewatin, for the most part hornblendic and chloritic, and massive diorites, with, in smaller volume, rocks of the quartz-porphyry type and soft, grey, calcareous schists. The schists are generally standing nearly vertically and strike, fairly uniformly, north and south. Where the rocks of this belt are exposed farther to the east, in Cranberry and Athapapuskow lakes, they have been described by Tyrrell[1] and Dowling.[2] On Athapapuskow lake, Dowling found mainly chloritic and hornblende schists and massive diorites, the general trend of the rocks being about northeast. Towards the more northerly extension of the area, along the outlet of the lake, quartz porphyries cut the schists and there occurs a band, west of the quartz porphyries, of well marked conglomerate with pebbles of red jasper, that is probably of lower Huronian age. Acid intrusives cut the basic rocks at many points.

On Cranberry lake, Tyrrell describes the rocks as consisting mainly of 'chloritic and sericitic schists, altered from diabases or clastic slates, cut by massive diorites and gabbro.'

The Reed Lake area and its extension down Grass river and about Wekusko lake are, like the tract to the west, underlain mainly by various dark coloured schists and diorites, but include quartz-porphyries and other acid intrusives.

The exposures about Reed lake are for the most part hornblende schists and massive, altered, dark green diorite-like rocks. On Grass river, below the lake the Keewatin is represented by massive quartz gabbros and coarse diorites which cross the river, in a belt about a mile wide, at the falls. At the first lake-like expansion of the river, which occurs about 6 miles below Reed lake, the Keewatin rocks form a very narrow belt with intrusive red granites on both sides of it. From a point opposite the inlet, northerly, for several miles, the rocks of this belt form a narrow fringe along the shore, the granite which lies to the east, or a red felsite which seems to be a marginal phase of the granite, coming to the shore from place to place in masses and tongues. An interesting conglomerate, which holds pebbles of red felsite, quartz-porphyry, white quartz, granite, and banded red jasper, forms part of the belt, indicating that, probably, Huronian strata are folded in with the Keewatin. The conglomerate on the Pineroot river, described by Dowling,[3] seems to be of similar character. The exact relationships of the conglomerate were not made out. It seems to be invaded by the felsites which form a marginal phase of the main granite mass, and which are in places quartz-porphyries, but includes pebbles that seem to be quite similar to the felsites and quartz-porphyry.

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[1] Geol. Surv., Canada, Annual Report Vol. XIII, 1890, Pt. F.
[2] Geol. Surv., Canada, Annual Report Vol. XIII, Pt. FF.
[3] Geol. Surv., Canada, Annual Report Vol. XIII, p. 33 FF.

The matrix of the conglomerate is made up of rounded particles of quartz-porphyry and felsite, cemented by interstitial crystalline quartz and chlorite; associated with the conglomerate and apparently merging on the one hand into it and on the other into quartz-porphyry is a breccia composed of irregular masses and smaller fragments of quartz, feldspar, aplite, felsite, and quartz-porphyry, arranged in a promiscuous manner in a ground-mass of the same composition.

The conglomerate in its extension along the strike northerly becomes schistose in structure, and passes upwards into a fine grained, quartz epidote rock, containing carbonate, which may originally have been a limestone.

This narrow belt, which skirts the sides of the lake expansion and continues down the valley of Grass river, forms a connecting band between the Keewatin area of Reed lake, referred to above, and the larger area of these rocks exposed about Wekusko lake. The rocks about Wekusko lake are, for the most part, diorites and schists derived from them, but embrace also many other rock types characteristic of the Keewatin, including hornblende and staurolite schists and nacreous, silvery schists derived from acid intrusives. The rocks of this area are cut by a great number of quartz veins, which vary in width from mere gashes to veins several feet wide. None was observed to carry valuable minerals.

The belt which crossed the river below Wekusko lake is separated from the lake area by a broad band of granite and granitoid gneiss. The surface is here largely drift covered, and few exposures are seen along the river. Those which outcrop are hornblende and chlorite schists and diorites.

Like the last named, the small area crossing Pipe lake and extending easterly, just south of Burntwood river, is made up mainly of chloritic and hornblende schists, and has apparently a trough-like structure, infolded in the enclosing granitoid gneisses.

Pipestone lake and part of Cross lake, Nelson river, lie in the western extension of a long belt of Keewatin rocks which extends eastward to Echimamish river and beyond, for a long distance down Hayes river. The rocks exposed about Pipestone and Cross lakes are principally chloritic and hornblende schists, diorites, and a conglomerate with schistose paste and pebbles of granite and diorite principally. The rocks of the belt are described in greater detail in the portion of this report dealing with Nelson river and the Hayes River route. They seem to occupy, towards the granite gneisses, the same relationship generally observed in northern Ontario, that of areas infolded in the granitoid rocks but also invaded by them.

Of the areas in the vicinity of Gods lake and Island lake, our knowledge is derived from notes made by A. S. Cochrane, accompanied by a set of specimens and a map.[1] The information is not sufficient to allow of the exact mapping of the areas. The rocks seem to consist mainly of hornblende and other schists and diorites, and they seem to have a very irregular distribution, but whether they occur in a number of small unconnected tracts or form two principal areas, it is not possible to say. Mr. Cochrane noted the occurrence of serpentine on the north shore of Island lake, and found very strong magnetic attraction at an island which he calls Iron island in the same neighbourhood.

The belt of Keewatin extending from Favourable lake to Sandy lake and down Severn river, was mapped by A. P. Low, who describes the rocks as consisting mainly of chloritic and altered hornblende rocks, with talc and hydro-mica schists. They were found in several places to be highly magnetic and to contain large quantities of pyrite.[2]

Huronian.

Included in the areas of Keewatin rocks mapped, are certain conglomerates, which from the fact that they hold pebbles that seem to have been derived from the Keewatin—for example, pebbles of banded jasper—are deemed to be younger than Keewatin, and, therefore, Huronian; they are folded in with those rocks and no attempt has been made, on the accompanying map, to separate the two. The large spread of horizontally bedded coarse sandstones which overlie the folded part of the Pre-Cambrian in the northwest corner of the area mapped are considered, for reasons which will be given in following pages, to be correlated with the upper Huronian, as that term is applied in Lake Superior geology, or with the Keweenawan.

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[1] Geol. Surv., Canada, Report of Progress 1878-79, Pt. C.

[2] Geol. Surv., Canada, Annual Report, Vol. II, 1886, Pt. F

Athabaska Sandstone.

A tract of upwards of 4,500 square miles in the corner of the area mapped is covered by beds of nearly horizontal sandstone; this forms the eastern part of an extensive tract of these rocks lying south and east of Lake Athabaska. The sandstone was first described by R. G. McConnell from exposures observed by him in 1888 at Pointe de Roche and at another point 7 miles east, on the south shore of Lake Athabaska.[1] McConnell described the rock as a siliceous sandstone which is 'usually coarsely granular in texture, but passes occasionally into a fine grained conglomerate. Its colour varies from white to dull red. Its bedding planes have been obliterated, but its general horizontal attitude is betrayed by the textural differences. It is cut by two systems of jointage planes, and, in weathering, breaks into huge blocks, some of which contain several hundred cubic yards of material.'

He noted the resemblance of numerous fragments of red and green, mottled sandstone occurring in the vicinity, to that found at Sault Ste. Marie. He used the descriptive name, Athabaska Sandstone, and concluded that it probably belongs, from its general character and position, to one of the divisions of the Cambrian.

The part of the area appearing on the map-sheet was outlined by J. B. Tyrrell in his exploration of the country between Athabaska lake and Churchill river, in 1892.[2] Tyrrell says:—

> 'This is an extensive series of generally horizontal red sandstone and conglomerate, resting over the uneven surface of the Archæan granites and gneisses. . . . . The formation is everywhere much the same in this district, consisting chiefly of a reddish, moderately coarse grained, quartzose sandstone. At some places, near the base of the series, especially on the north shore of Lake Athabaska, the rock becomes a coarse conglomerate with well rounded pebbles of white, clastic quartzite like that of the neighbouring Huronian rocks.'[3]

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[1] Report on a portion of the District of Athabaska comprising the country between Peace river and Athabaska river north of lake. By R. G. McConnell, B.A., Geol. Surv., Canada, Annual Report (New Series) Vol. V, 1890-91, Part 1, 51 D.

[2] Geol. Surv., Canada, Annual Report 1895 (New Series) Vol. VIII, pp. 17-180.

[3] These Huronian rocks are described at page 17D in the same report as occurring in three small areas on the north shore of Lake Athabaska, the most important extending for 16 miles along the shore east of Black bay and consisting of a hard, white, crushed quartzite, in which heavy bedding can often be detected and which form a wide syncline with a northerly trend. On the eastern edge of the area, Tyrrell notes an extensive development of hematite, often associated with a coarse quartzite breccia, which was seen to extend a long distance inland along the strike of the quartzite.

'In other places, as on Wapata lake, it is a fine grained, thin-bedded, red, shaly sandstone, mottled with rounded spots of a greenish-grey colour.'

'It is almost everywhere nearly horizontal, the exception to the rule being slight and local. It was not found to be cut by eruptive rocks except at one point on the west shore of Cree lake where a dyke of coarse, light green, uralitic diabase has cut through it and alters the sandstones on both sides to a hard quartzite.'

'On account of the generally horizontal position of the beds, and their similarity in character throughout, it was impossible to determine its greatest or total thickness, but near the east end of Lake Athabaska cliffs of sandstone rise on the south shore to the height of between 400 and 500 feet, giving a vertical section of over 400 feet at this point.'

Tyrrell also states that in 1893 'in the country northward, toward Chesterfield inlet, similar sandstones were found overlying the Archæan associated with quartz-porphyries, diabases, etc., like those of the Keweenawan rocks of Lake Superior. The likeness is so pronounced throughout that there would seem to be little doubt that the two sets of rocks belong to the same geological horizon.'[1]

The boundaries of the part of the Athabaska sandstone area appearing on the map were fixed by Tyrrell, who found all along Stone river from Black lake easterly to a rapid three-fourths of a mile below the mouth of Waterfound river, occasional exposures of sandstone, all very similar in character, generally horizontal and undisturbed, and none showing any great thickness. About Crooked lake the measures are concealed, so that the immediate contact of the sandstone with the underlying gneisses which are exposed just above the lake was not here seen.[2]

The eastern boundary of the sandstone which skirts probably the west shore of Wollaston lake was assumed from the occurrence there of angular masses of sandstone, which are absent from the drift elsewhere on the lake, together with the general sandy character of the surrounding country.[3]

Similar sandstones, associated with intrusives of various kinds, have been found to cover many extensive tracts in other parts of northern Canada. These include a large area west of Chesterfield inlet,[4] an area about the east end of Great Slave lake,[5] and one extending from the eastern side of Great Bear lake to Coronation gulf and the shores of the Arctic ocean.[1]

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[1] Idem.
[2] Idem, p. 85.
[3] Idem, p. 89.
[4] Geol. Surv., Canada, Annual Rept. (New Series) Vol. IX, 1896, Part F.
[5] Geol. Surv., Canada, Annual Rept. (New Series) Vol. II, 1886, Part R.
Geol. Surv., Canada, Annual Rept. (New Series) Vol. XII, 1899, Part A.

The beds are described in greater detail by Tyrrell in writing of the Chesterfield Inlet area:—

'The Athabasca sandstones and conglomerates represent the basal portion of the Cambrian in the northern part of the country shown on the accompanying map. They consist of 400 feet or more of reddish, thick-bedded sandstone or conglomerate, often showing false-bedding, and are comparatively unaltered and undisturbed over large areas. In some places, as on the islands near the northwest shore of Doobaunt lake, they dip regularly at a moderate angle.'

'The rock varies from a coarse conglomerate to a fine-grained, red, mottled sandstone. The pebbles in the conglomerates are well-rounded and waterworn, and consist almost entirely of white clastic quartzite like that of the Huronian. The occurrence of quartzite pebbles to the almost total exclusion of pebbles of Laurentian rocks, would indicate that these Cambrian strata were deposited off a shore composed very largely of Huronian quartzites.'

'The Athabasca sandstones are cut by dykes and masses of both acid and basic eruptive rocks. The acid eruptives were first met with in a hill of red quartz-porphyry at Teall point, on the west shore of Doobaunt lake. A similar massive quartz-porphyry forms a heavy east-and-west-dyke some distance farther north on the shore of the same lake, and in the vicinity of the dyke the surrounding conglomerate is very much hardened, so that it breaks indifferently through the matrix or through the pebbles. In places the porphyry contains little or no quartz.'

'Towards the north end of Doobaunt lake, the orthoclase of the porphyry is replaced by plagioclase, thus forming an andesite or dacite. This andesite is largely developed, and seems to underlie a large tract of country along the Doobaunt river between Lady Marjorie lake and the Forks, and again it was found on the islands towards the east end of Baker lake.'

'Dark green basic eruptive rocks, chiefly, or perhaps exclusively in the form of dykes, are more or less extensively developed throughout the area covered by the Athabasca series, often altering these rocks into a quartzite or quartzitic conglomerate.'

'On Doobaunt lake, and on the Doobaunt river near the Forks, most of these dykes are of more or less typical diabase, showing ophitic structure, with interlocking lath-shaped crystals of plagioclase, between which are crystals or crystalline masses of augite, often altered to chlorite. Apatite and iron ore are also usually present.'

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[1] Geol. Surv., Canada, Annual Rept. (New Series) Vol. II, 1886, Part R.
Geol. Surv., Canada, Annual Rept. (New Series) Vol. XII, 1899, Part C.

'The heavy dyke, cutting the conglomerate at the gorge above Grant lake, has a much newer appearance, being composed of a dark pitchstone with glassy matrix, through which are scattered many minute feathers of iron ore.'

'The heavy diabase dike, crossing the Telzoa river at Loudon rapids, cuts the surrounding acid eruptive rocks, and is clearly newer than them. In most cases, however, the acid and basic eruptive rocks were not seen in contact, and their relative ages were not determined; but since the latter are also common in the Huronian and Laurentian, it would seem probable that some are older, and some are newer than the acid eruptives.'

'Though fossils were carefully looked for in the Athabasca sandstones, none could be found, so that the age of this formation must be determined on stratigraphical and lithological grounds alone.'

'That they are separated from quartzites of the Huronian (Keewatin) by a great unconformity, is shown by the fact that the conglomerates are composed largely of rounded and waterworn pebbles of these quartzites, which had, therefore, been altered, hardened, and recemented with interstitial silica before they were broken down by meteoric agencies, and carried out into the water off the shore to form the later conglomerates. They are also certainly older than the flat-lying Cambro-Silurian limestones which were seen on Nicholson lake, for, though the two were not seen in contact, pebbles and boulders of Trenton limestones were found in many places, evidently derived from other outliers of the limestone than the one seen, and none of them showed any signs of alteration from contact with the numerous trap flows that cut the sandstone and conglomerate. Therefore, since they hold a position unconformably above the Huronian and below the Cambro-Silurian, they may be assigned with probability to the Cambrian. Lithologically the whole terrane presents a remarkable resemblance to the red sandstones and Cambrian quartz-porphyries of the Keweenawan rocks of Lake Superior. This resemblance is so strongly marked that small specimens of rocks from the shore of Doobaunt lake are usually indistinguishable from specimens from Lake Superior. The two terranes are regarded as holding similar positions in the geological time-scale.'[1]

The question of the age of the Athabaska sandstone has been somewhat fully dealt with in the reports already cited. The authors of these reports, together with Sir J. Richardson, Bell, and McConnell, are agreed as to the probable correlation of these areas with the Keweenawan of Lake Superior; the correlation being based mainly on lithological similarity but being also in accord with their stratigraphical position so far as this has been determined.

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[1] Geol. Surv., Canada, Ann. Rept. (New Series) 1896, Part F.

There seems to be great probability that rocks of about the age of the Athabaska sandstones or of Animikie and Keweenawan age occur under the Palæozoic sediments near the shores of Hudson bay. Though they have not been recognized in place on either the Nelson or Hayes, the only rivers which have been examined, the presence in the valleys of these rivers of great numbers of boulders, which closely resemble the rocks of the Keweenawan and Animikie, makes it probable that the ledges from which they were derived are concealed beneath the drift or occur somewhere in the neighbourhood. Bell records on the lower stretches of the Nelson, "boulders and pebbles of the drift of this neighbourhood are made up largely of the rocks of the supposed equivalents of the Nipigon series of the east coast of Hudson bay. Specimens of almost every variety of these strata may be picked up along the banks in this part of the river."[1]

Joseph Robson, describing an exploration of the lower Nelson made by him in 1745,[2] says:—

'As we walked along the river we saw many stones in shape and colour like a cannon ball; and upon breaking them against larger stones we found that the inside looked like iron. Up another river, a few miles eastward of York Factory, there is a bank abounding with these round stones.'

This description of Robson's applies very aptly to concretions which are common in the Animikie of Lake Superior, weathering out from the slates on Kaministikwia river, to form shingle 5 inches in diameter.

Ordovician.

A belt with an average width of about 50 miles, made up almost entirely of magnesian limestones of Ordovician age, extends from Lake Winnipeg nearly to Lac LaRonge. To the south it is overlain, apparently conformably, by beds of limestone which resemble closely the Ordovician beds but which contain a fauna that establishes their age as Silurian. To the west a heavy cover of recent sands and the overlap of Cretaceous beds, which at Wapawekka lake lie directly upon the Pre-Cambrian surface, hide its possible extension.

A complete section of the beds is nowhere seen at any one locality, since they lie nearly horizontally with a gentle slope southwesterly, or are broadly undulating.

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[1] Geol. Surv., Canada, Report of Progress, 1878–79, Pt. C.

[2] An account of six years' residence in Hudson Bay from 1733 to 1736 and 1744 to 1747, by Joseph Robson, late surveyor and supervisor of buildings for the Hudson's Bay Company. London, 1752.

Another area of Ordovician rocks occupies the northeastern part of the area covered by the map-sheet. They form part of the broad expanse of Palæozoic sediments that extends from the basin occupied by Hudson bay and James bay, inland over the Pre-Cambrian peneplain. The width of the belt is greatest in the region to the southwest of James bay, where it extends inland upwards of 250 miles. In the lower part, where the belt is broadest, the Ordovician is entirely concealed by the overlap of Silurian and Devonian beds. Where the belt appears upon the area of the map the width is about 125 miles, nearly 100 of which are underlain by Ordovician.

Both in lithological character and in their fossils, the rocks of these two, now widely separated areas, closely resemble one another; it, therefore, seems probable that at one time they spread widely over the peneplain surface and formed a continuous sheet.

The southern area is made up principally of magnesian limestones with, at the base, rather coarse, white and dull red sandstones. The limestones are, for the most part, fossiliferous, and are separated from the conformably overlying Silurian limestones solely by this means.

No complete section of the beds was seen at any one place, and the gently undulating attitude of the strata makes it difficult to construct a full section from the exposures outcropping at points widely separated. In the neighbourhood of Cormorant lake and to the west of it, the succession seems to be, in descending order:—

40 feet....Very thick bedded, fine-grained dark buff coloured, magnesian limestone.

15 " ....Compact, yellowish buff, moderately thick bedded magnesian limestone, with many impressions of large coiled shells of cephalopods.

6 " ....Thin bedded, hard, fine yellow-buff magnesian limestone, fine-grained and showing conchoidal fracture.

9 " ....Thick bedded, hard, yellowish, magnesian limestone, breaking, on cliff faces, into roughly discoidal pieces of irregular shapes.

6 " ....Thin bedded, fine, red marbled, brown-buff magnesian limestone with the texture of a lithographic stone and nodular at the base.

3 " ....Thin bedded, reddish magnesian limestone, weathering very rotten and stained with iron oxide.

8 " ....Thin bedded, reddish, easily disintegrating magnesian limestone.

20 " ....Red and white mottled or blotchy, impure, magnesian limestone in somewhat heavy beds.

10 " ....or more of dull red and white coarse, soft quartz sandstone.

Dowling published a tabulated list of the fossils collected from the Ordovician rocks of Manitoba in the Annual Report of the Geological Survey for the year 1898, pp. 48 F to 53 F.

The following species are recorded by Tyrrell from the rocks of the country north of the Saskatchewan, which are considered to be of similar age. To these are added a few other species recognized by Mr. Whiteaves in a collection made at Cormorant lake, and by Mr. Percy Raymond in a collection from Deschambault lake:—

In the limestones:—

Receptaculites oweni.
Columnaria alveolata.
Columnaria (Palaeophyllum) rugosa.
Streptelasma robustum.
Calapoecia canadensis.
Stictopóra acuta.
Orthis testudinaria.
Leptoena unicostata.
Plectambonites sericea.
Dinobolus parvus?
Cyrtodonta, sp.
Maclurea manitobensis.
Liospira, sp.
Murchisonia or *Loxonema,* sp.
Trochonema or *Pleurotomaria,* sp.
Orthoceras, sp.
Endoceras subannulatum?
Triptoceras lambii.
Gyroceras submamillatum?
Bumastes trentonensis.
Cheirurus pleurexanthemus.

In the sandstones:—

Ctenodonta subnasuta?
Pleurotomaria, sp.
Murchisonia or *Loxonema.*
Helicotoma, sp.
Bucania buellii?
Bellerophon, sp.
Orthoceras semiplanatum or *planoconvexum.*
Endoceras (Narthecoceras) crassisiphonatum.

To these the following were added from collections made at Cormorant lake, identified by Mr. Whiteaves, and at Deschambault and Suggi lakes, identified by Mr. Percy Raymond:—

From Cormorant lake:—

Pasceolus (Cyclocrinus) spaskii? Eichwald.
?Zaphrentis affinis, Billings. Teste, Lambe.
Nyetopota billingsii, Nicholson. Teste, Lambe.
?Labechia ohioensis, Nicholson. Teste, Lambe. A fragment.
Rhynchotrema, sp.
Strophomena deltoidea?
Strophomena trentonensis?
Pleurotomaria?
Ophileta?

From Deschambault and Suggi lakes:—

Platystrophia lynx, Eichwald.
Receptaculites oweni, Hall.
Clionychia, sp.

Northeast Boundary of Ordovician.

The Ordovician limestones terminate northerly in most places in almost perpendicular cliff faces from 20 to 40 or more feet high, the lower parts of which are hidden by a talus of huge blocks of limestone which have fallen from above owing to the undermining of the cliff by the weathering away of the lower beds, which, in some cases, as at Amisk lake, consist of limestones that are thin bedded and less resistant than the upper beds, and in others, as on Ballantyne bay, of easily disintegrating quartz sandstones.

In a broad zone near the edge, the limestones are intersected by many cracks along joint planes, some roughly parallel to the cliff fronts and others extending back from it almost at right angles. These fractures have been widened, probably largely by the expansion of ice within them, until some of them now form miniature gorges large enough for the passage of a man, in which the passing traveller may find ice in midsummer. Huge quadrilateral blocks are thus separated by these gorges from the main body of limestone. This feature strongly impressed Alexander Henry,[1] who thus speaks of it in a description of a trip through Amisk (Beaver) lake in 1776:—

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[1] Travels and Adventure in Canada and the Indian Territories between the year 1760 and 1776, by Alexander Henry, Esq., 1809.

> 'In recrossing Beaver lake the wind obliged us to put into a bay which I had not visited before. Taking my gun I went into the woods, in search of game; but I had not advanced more than half a mile, when I found the country almost inaccessible by reason of masses of rock, which were scattered in all directions; some were as large as houses and lay as if they had been first thrown into the air and then suffered to fall into their present posture. By a circuitous route, I at last ascended the mountain, from one side of which they had fallen; the whole body was fractured and separated by large chasms. In some places parts of the mountain, of half an acre in surface, were raised above the general level. It was a scene for the warfare of the Titans or for that of Milton's angels.'

The Hudson Bay belt of Ordovician is exposed on the rivers flowing to the bay, in a broad band, extending inland, measured on Nelson river, for a distance of 125 miles. Of this width 60 miles, nearest the coast, are covered by the overlap of the conformably succeeding beds of the Silurian.

The rocks making up this area of Ordovician are similar in general lithological character to those of the southern area. They are best exposed on Nelson river, where, between the edge of the overlapping Silurian and the Pre-Cambrian complex, many ledges occur in the river bed and along the banks for a distance of several miles. The rocks consist of magnesian limestones or dolomites, generally buff coloured or mottled and somewhat arenaceous in composition. They lie in low undulations here and there, but are for the most part horizontal. Many of the beds are fossiliferous, and from those occurring at the three limestone rapids a collection was made by Dr. Bell and determined by Mr. Whiteaves.[1] These fossils seem to be sufficiently diagnostic to fix the age of the beds as about the same as that of the Winnipeg limestones and Ordovician.

Silurian.

Rocks holding fossils which are undoubtedly of Silurian age, and probably belong to about the Niagara division of that system, are exposed at many points along the Saskatchewan between Grand rapids and Cumberland lake. Lithologically they are magnesian limestones, usually of somewhat granular texture and of light buff or yellowish colour. They weather almost white and that characteristic, apart from the contained fossils, seems to constitute the most striking difference in appearance between them and the underlying

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[1] Geol. Surv., Canada, Report of Progress, 1878-79, Pt. C. Appendix I.

PLATE X.

22106--p. 62.

Palæozoic, magnesian limestones, Namew lake: canoemen in the foreground.

Photo by W. McInnes, 1919.

and structurally conformable Ordovician (Plate X). On the map the boundary between the two is arbitrarily drawn to include on the one side all the measures known to hold Silurian fossils, and on the other those holding Ordovician forms. So far as seen, there seems to be no stratigraphical break between the two systems. The rocks of the two seem to have been laid down under pretty much the same conditions; lithologically, they are very similar, and both lie in a horizontal or gently undulating attitude. A much closer examination than has been possible would, therefore, be necessary to separate the two systems with exactness.

In the region under consideration the Silurian, occupying, as it does, the low valley of the Saskatchewan, is concealed over large areas by surface deposits of boulder clay and recent alluvium; it is best exposed at Grand rapids at the mouth of Saskatchewan river, and at that place the most comprehensive collection of its fossils has been made. For a description of the section exposed there, with lists of fossils, the reader is referred to the detailed description of the river in another part of this report.[1]

In the northeastern part of the area mapped, bordering the shores of Hudson bay and overlapping conformably the Ordovician, is another belt of magnesian limestones of Silurian age. They form part of a gradually widening band of strata of this age, that extends southwards, down the shores of Hudson bay and James bay. The rocks are described in greater detail in the section devoted to Nelson river, since only on that river are the rocks exposed. On Hayes river the lower stretches where, presumably, the underlying rocks are Silurian, show no exposures of solid rock. Many of the rivers, crossing the belt farther east, give good sections of these rocks, and from them large collections of fossils have been made.[2]

The south boundary of the belt of Silurian is, therefore, fixed on the accompanying map from the outcrops exposed on Nelson river. On that river the lower 62 miles, measured in a straight line from Beacon point, are entirely through drift, and show no solid rocks in situ; above this point, for 6 miles farther up the river, occasional exposures of horizontally bedded dolomite outcrop from the banks, the upper one rising from the water in a sheer cliff 30 feet in height.

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[1] See also Geol. Surv., Canada, Palæozoic Fossils, Vol. III, Part III.
[2] Geol. Surv., Canada, Palæozoic Fossils, Vol. III, Part IV.

The rock is a fine-grained, soft, magnesian limestone of yellowish-grey colour, generally somewhat earthy and impure, but in some beds apparently a tolerably pure dolomite. A few of the beds are a foot or more in thickness, but, generally, the rock is quite thin-bedded. The only fossil observed was an obscure *Pentamerous*, the species of which could not be determined.[1] This fossil is abundant in some of the beds, and its occurrence fixes their age.

Devonian.

Rocks of Devonian age were recognized at only one place in the region, namely, on the south shore of Lac LaRonge; and, there, they occur in the form of angular blocks and debris, making up the shores and banks, and have not been proved to occur in place. From the mode of occurrence of the loose material in the banks and flooring the bottom of the lake, there seems to be little doubt that the rocks are in place underneath. To the west, in similar relation to the overlying Cretaceous beds, strata of this age have been recognized south of Lac LaPlonge, and it seems probable that the Lac LaRonge beds represent the extension easterly of the western area. To the east, also occupying a similar position, like rocks have a wide development about Lake Winnipegosis.

The strata at Lac LaRonge comprise buff-coloured, magnesian limestones, calcareous sandstones and conglomerate, in which pebbles of limestone and quartz are cemented by a calcareous, arenaceous paste.

Fossils collected at the Lac LaRonge locality were submitted to Mr. Lambe, of the Geological Survey, who says of them[2]:—

'The Lac LaRonge fossils consist of mature and immature specimens of *Atrypa reticularis*, L., and of portions of the stems of crinoids. Some of the mature specimens of the brachiopod show the "marginal fringe," so well preserved in a number of the examples of this species from the dolomites of the Winnipegosis district. The fragments of crinoid stems agree in form with those from the Winnipegosis region, referred by Dr. Whiteaves to a species of Ctenocrinus. They are of Devonian age, at about the horizon of the Stringocephalus zone (middle Devonian).'

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[1] Geol. Surv., Canada, Report of Progress, 1877–78, p. 12 CC.
[2] Geol. Surv., Canada, Summary Report, 1909, p. 154.

Cretaceous.

The Cretaceous section exposed along the south shore of Wapawekka lake is made up principally of very pure, white, quartz sand, in places so loosely coherent as to resemble a recent sand deposit and in places indurated so as to form a hard sandstone and even a quartzite. Layers occurring irregularly in the sand are nearly black from carbonaceous matter which coats and cements the grains of quartz. In the most southerly exposures these layers are represented by bands of fairly good lignite. In other irregular layers or streaks the grains are cemented by iron oxide. Lenticular patches of coarse grit and of conglomerate very irregularly bedded and running irregularly into the sand also occur; the grit is made up of grains of quartz similar to those making up the sand but of larger size and cemented by iron oxide, and the conglomerate encloses, in a similar matrix, larger, white, calcareous pebbles and nodules of ironstone.

The sands in many places show conspicuous false-bedding. The grains of quartz are fairly uniform in size, 93 per cent passing through a 60-mesh sieve, are well rounded, excepting the very small grains, and have a frosted appearance, like ground glass.

At the most southerly point in the lake the section exposed is, in ascending order:—

2′—0″...Concealed.
6′—0″ ..White quartz sand, fine, indurated, streaked rusty.
2′—0″...Lignite (Plate XIX).
1′—0″...White quartz sand with some carbonaceous matter.
1′-10″...Lignite.
17′—0″...White quartz sand, false bedded.
6′—0″...Sandstone (an indurated form of the sand).

After an interval of about 3 miles without exposures, the scarped banks of sand come to the shore and continue to form cliffs for 5 miles. The same white quartz sands, with conspicuous false-bedding and with, here and there, bands nearly black from carbonaceous matter coating the quartz grains, and rusty streaks that follow the irregular bedding, continue for 5 miles farther. At a point 6 miles east of the section given above the following section was measured:—

20′—0″...Concealed by talus.
3′—0″...Rusty grit and conglomerate with white calcareous pebbles and pebbles of nodular iron stone.
0′—8″...Carbonaceous sand.
2′—6″...Irregularly stratified sandstone occurring in lenticular patches.
8′—0″...Rusty grit and conglomerate very irregularly bedded and running irregularly into the sands and merging upwards into them.
15′—0″...White quartz sand, to surface.

At a number of places, where the scarped banks were absent, their place is filled by sections, from water level up of:

4 feet–8 feet..Rusty conglomerate that is till-like in structure but roughly stratified in places and holding very deeply rotted boulders of gneiss resembling Pre-Cambrian gneiss.
3 feet–4 feet..Thinly and evenly laminated sands cemented by clay and having the appearance of indurated clay.

Whether these last mentioned sections are irregularly distributed basal beds that are absent or concealed in the other sections, or represent a later rearrangement of the materials of the general sections occurring in intervals where the sands have been eroded away, was not ascertained.

The exposures seem to be best correlated with similar sands which occur over a wide area farther west, where they are known as the tar sands. The tar sands, which are well exposed along Athabaska river and at other points, have been described by McConnell and others, and it is pretty well established that they are of Dakota age.[1, 2]

The Cretaceous sediments of Wapawekka lake apparently overlap the Palæozoic, and rest directly upon the rocks of the Pre-Cambrian complex. They were not found in actual contact with the underlying rocks, but are separated, at the eastern end of the cliffs, by an interval of low land only 800 yards wide, from exposures of massive, hard, dark, fine-textured quartz-diorite, that is evidently Pre-Cambrian, and probably belongs to the Keewatin division of the Pre-Cambrian, since it is followed by chloritic and hornblende schists and diorites that are of Keewatin character. At the western end of the cliffs low land intervenes between the Cretaceous sands and exposures of Pre-Cambrian gneiss; the Pre-Cambrian in both cases showing the effects of stress and folding that everywhere characterize these rocks, while the Cretaceous beds show little or no effects of pressure and lie about in the attitude in which they were laid down. Sections of Cretaceous rocks were seen only in the scarped banks along the south shore of Wapawekka lake. Inland from the sand cliff a plateau extends southerly for several miles to the slopes rising to form Wapawekka hills.

In places on the plateau surface the white Cretaceous sands come to the surface, looking like low snow drifts rising through the scanty vegetation; but for the most part a cover of drift material

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[1] Geol. Surv., Canada, Vol. V, 1890–91, Pt. D.
[2] Ottawa Naturalist, Vol. XII, 1898–99, p. 40.

hides the underlying sediments. The greater part of the drift is made up of reassorted sands derived from the Cretaceous beds, but it includes as well boulders from the Pre-Cambrian. Steep ridges and low rolling hills, trending parallel to the face of the higher hills and apparently of morainic origin, rise here and there to heights of 100 feet or more from the plateau surface. They are made up, so far as observed, of well rounded boulders exclusively of Pre-Cambrian rocks.

A partial section of Cretaceous rocks making up the Paskwia hills was seen where the rocks are exposed in gullies worn by streams descending the northerly facing slopes. An estimated section along these gullies, compiled mainly from exposures observed in the trench worn by Nabi (man) river, is as follows, in ascending order:—

35 feet–40 feet..	Thick bedded, soft grey arenaceous oil-shale or thin-bedded sandstone, holding the remains of fishes which seem to be *Enchodus shumardi*, large bivalves, *Inoceramus labiatus* (Schlotheim) and foraminifera..
0′-6″..........	Compact, impure limestone with many casts of *Ostraea congesta*, Conrad.
120 feet or more.	Soft, fissile, light grey (almost black when wet) oil-shales, holding the comminuted remains of fishes and many foraminifera.
15 feet......	Clay iron-stone in beds 6 inches to one foot in thickness divided by thin partings of shale.
10 feet.	Soft, fissile, grey shale that seems to be similar to the oil-shales below.

Overlain, to the surface, by 10 feet or more of boulder clay containing many boulders of limestone and a few of Pre-Cambrian gneiss and granite.

Mr. Whiteaves, who examined the fossils from the section given above, expressed the opinion that they were probably of Niobrara age.

The fossils enumerated have a wide range in the Cretaceous, but in northern Manitoba *Enchodus shumardi* is most abundant in the Niobrara formation, which with the underlying Benton makes up the Colorado series of the upper Cretaceous. The occurrence of great numbers of foraminifera in the shales is also characteristic of the Niobrara beds of northern Manitoba.

The thickness of the Niobrara in Manitoba has been computed to be from 130 to 200 feet, comprising grey calcareous shales, which pass downwards into the shale of the Benton.

The base of the section given above lies at a height of 400 feet or more above the bed of Carrot river, where, at the rapid above

Red Earth Indian reserve, ledges are exposed that are thought to represent the Dakota division of the upper Cretaceous. They consist of 5 feet of very soft quartzose sandstone deeply stained with iron oxide, lying in undisturbed heavy beds that show false-bedding, and hold nodules and irregular masses of iron pyrites. In places the sandstone becomes a fine conglomerate in certain layers with pebbles of gneiss and other rocks, and in places it contains carbonaceous material resembling the comminuted remains of plants. The soft sandstone is overlain by hard, white quartz sandstone with distinctly red-purple tinge, which is strongly ripple-marked on some surfaces.

Fifty miles farther up the Carrot river from the rapid at which the sandstones are exposed and at an elevation of about 400 feet above that point, grey oil-shales quite similar to those of Paskwia Hills section form the low scarped banks of the river.

There is thus an interval of 400 feet or more between the observed beds of Dakota sandstone and those of Niobrara shale. A great part of this interval, which on the side of the Paskwia hills and in the valley of Carrot river is covered by deposits of boulder clay and by later stratified sands and clays, is without doubt occupied by the shales of the Benton. Shales which, from their relative elevation, would fall into this gap and which he considered to be of Benton age, were observed by Mr. J. B. Tyrrell in the bed of the Saskatchewan below Birch islands.[1]

Post Tertiary and Recent.

Post Tertiary and Recent deposits have a wide development over the region, especially in the southwestern part, where, over large areas, they completely conceal the underlying, solid rocks.

Boulder clay forms a widespread mantle, extending inland from the shores of Hudson bay, in an unbroken sheet for about 150 miles. Along the rivers flowing to the bay, good sections are afforded by the scarped banks which, in places, rise, with almost cliff faces, to heights of from 80 to 100 feet above the river. In the interior the mantle has been generally removed by erosion, but remnants remain here and there in the Churchill and Saskatchewan valleys and at other points. Scattered irregularly over the region are other deposits of glacial origin, comprising morainic and other accumulations of boulders and gravel.

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[1] Information communicated to the writer by letter.

Lacustrine clays cover large areas within the district. They belong to the age of the declining glaciers, when large lakes extended southerly from the retreating ice front and were fed largely by streams flowing from the melting glacial ice. Carrying, as they did, large amounts of suspended sediment, the waters of these lakes rapidly silted up their basins and formed the thick deposits of clay that are now widespread. The principal area of these clays lies west of Nelson river and north of the Saskatchewan; it is described more at length in the sections of this report devoted to agricultural land and to Burntwood river.

Marine clays have a wide distribution in the northern part of the district. They occur as small, isolated areas, overlying the boulder clay of the Hudson Bay slope. These without doubt are the remnants of a once continuous sheet, which covered the region extending inland from the bay to distances of 130 miles or more.

On Churchill river marine fossils have been found up to an elevation of about 350 feet above the sea, and similar clays extend farther up the river, though so far as observed, without fossils. On Nelson river shells were found in the clays at an elevation of about 200 feet, and the clays were observed at points considerably higher. Fossil shells are quite plentiful in most of the beds; from those on Churchill river the following were collected:—

Mya arenaria.
M. truncata.
Saxicava rugosa.
Tellina proxima.
Pecten islandicus.
Cardium islandicum.[1]

In the region bordering the bay, farther to the east, the presence of these clays has been recognized on all the rivers explored; on Winisk river they have been found at an elevation of about 350 feet above the sea,[2] and in a branch of Albany river at an elevation of 380 feet.[3] The depression of the land, in reference to sea-level, during the period immediately following the deposition of the boulder clays was, therefore, at least as much as 380 feet, and probably a little more.

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[1] Geol. Survey, Canada, Report of Progress, 1878-79, p. 21 C.
[2] Geol. Survey, Canada, Vol. XV, 1892, pp. 104-105 A.
[3] Geol. Survey, Canada, Report of Progress, 1871-72, Pt. C.

Recent alluvium forms the low lands, bordering the rivers and lakes. In many cases sedimentation is now going on actively; this is especially true of the lower part of the valley of Saskatchewan river, where lakes are being silted up rapidly and, generally, aggradation is going on in a very marked manner.

DETAILED DESCRIPTION OF RIVERS AND LAKES.

Nelson River.

The Nelson river, flowing from the northeasterly corner of Lake Winnipeg, expands 4 miles below to form Playgreen lake, about the shores of which are many exposures of reddish, biotite gneiss generally well foliated but in places granitoid in structure. A thin mantle of clay covers most of the surface, and the underlying rock can be seen only here and there, where the clay has been removed by denudation. From Playgreen lake the river flows in two main channels, one leaving the lake in four small branches about 10 miles down its northeast shore, and the other flowing out 35 miles farther north, from the extreme end of the lake. The most direct branch of the first named channel is commonly followed by boats, and by it Little Playgreen river is reached, where the branches unite and where is situated Norway House, a well known post of the Hudson's Bay Company.

Much of the surface surrounding Little Playgreen lake is clay covered, but exposures of rock are sufficiently numerous to indicate that biotite gneisses, varying from granites to well foliated gneisses, underlie the whole. From the lake down to High Rock, about 3 miles below the Sea-river fall, exposures of similar gneisses are common, the foliation preserving a general northeasterly strike. Below, the river follows a great number of canal-like, rock-bound channels between islands, the shore showing almost continuous exposures of similar gneisses disturbed and cut by many irregular masses and veins of pegmatite. At the rapid next above Pipestone lake occur exposures which indicate at least four distinct ages for the rocks. A well foliated, biotite gneiss, which encloses blocks of a fine black hornblende gneiss, is invaded by a hard, compact quartzose rock, probably a quartz-diorite, and the whole

Plate XI.

22106—p. 70.

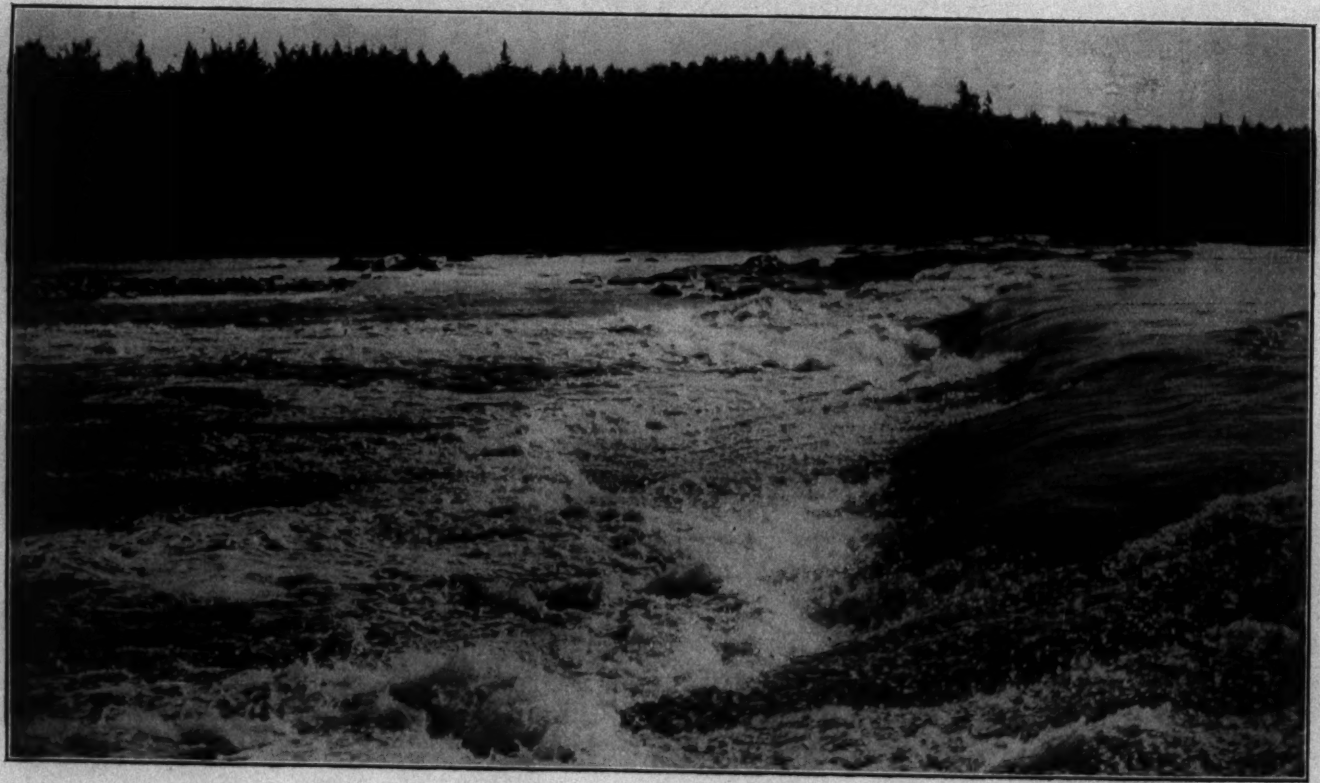

Photo by R. W. Brock, 1910

Sea-river fall, Nelson river.

previously enumerated set is invaded by a dyke-like tongue of dark blue-grey, fine diorite, which cuts the country-rock clearly and sends long, narrow arms into it. Well foliated biotite gneisses, striking about east and west, continue to Pipestone lake, where a broad belt of chloritic and hornblende schists, diorites, and conglomerates is infolded in the gneisses, to which it conforms in strike. The conglomerates are made up of a chloritic, schistose matrix enclosing well rounded pebbles principally of granite but including diorites. Near the northern edge of the belt, ledges of a very highly altered chloritic rock, probably derived from a hornblendite, occur. This is the rock used by the Indians for pipe bowls, and gives the lake its name.

'On the southern shore of the main body of Pipestone lake the prevailing rock is a dark green, laminated, calcareous, hornblende schist, with vein-like streaks and lenticular patches of white quartz. It runs N. 70° W., and dips southward at an angle of about 75°. On an islet about a mile off the central part of this shore there is a softer hornblendic schist with laminæ of white calcspar and bunches of quartz and chlorite, associated with a glossy-surfaced chloritoid schist. An island about a mile to the northwest of the last is composed of massive grey, rather coarsely crystalline diorite. The islands in the outlet of the lake consist of green hornblende and mica-schists, with irregular veins of bluish-grey quartz conforming with the stratification, which here runs N. 70° W. and dips northward at an angle of 80°. Along the strait 5 miles in length, which connects Pipestone lake with Cross lake, the rocks on both sides consist of grey mica-schists with pebbles of different kinds and rounded grains of quartz either closely crowded together or scattered sparingly through the mass. At a point on the south side of the strait, and 2 miles from Pipestone lake, a conglomerate band occurs in the midst of a grey, rather soft and somewhat fine-grained mica-schist running N. 55° W., dips W.E. angle 80°. The pebbles in the conglomerate range from coarse sand up to the size of a child's head. Most of them approach a spherical form, and consist of fine-grained, hard, grey syenite. Others are of white quartz, and are also well rounded.' . . . . . 'On the eastern side of the (Indian) Reserve island and adjacent, smaller islands, from Otter island to Bigstone point the rock is a dark green calcareous hornblende schist with some fine-grained mica-schist of the same colour. The strike is S. 60° W., dip southeastward, angle 85°. At Bigstone point the Laurentian gneiss begins. A dark grey, coarsely crystalline, massive diorite occurs along the narrows on the east side of the Reserve island, and the opposite point.' . . . . . .
"Two miles farther north, a light grey, massive quartzite was found

on both sides of the same channel. The extreme north point of the Reserve island is formed of a dark grey granite or granitoid gneiss in which the lamination is very obcure. A small dyke of fine-grained, dark grey dolomite running N. 5° W. here cuts this rock. Grey mica schist was found on all the islands visited in the western part of Cross lake, between the Reserve island and the outlets.' . . . 'The northwest shore of Cross lake is formed of Laurentian gneiss."

Just beyond the northern edge of the belt, on Cross lake, occur altered red granites with somewhat opalescent, bluish quartz, that resemble closely certain granites occurring along the contact with Keewatin bands in Rainy River district, Ontario. Between Cross lake and Sipiwesk lake the river is divided up into a number of channels, flowing with rapid current between bare, sloping ledges of biotite granite gneiss and interlaminated coarse white and fine black gneiss, in places garnet-bearing. These gneisses are cut here and there by intrusive red granite and, at one place, by a dyke of hard, fine, nearly black diorite.

From a point 2 miles below Sipiwesk lake the low gneiss hills, rising from both shores, are quite bare, and a few miles farther on the banks become low and sand covered, with only an occasional exposure of gneiss protruding through them. Below Clearwater river and continuing to Split lake, biotite granite gneisses in low rounded ledges form the banks, with intervening depressions between the ridges covered with clay.

Dr. Bell, who made an examination of the portion of the river below Sipiwesk in 1877, thus describes it:—

'The whole of the waters of the Nelson river appear to have come together in this stretch for the first time since leaving Great Playgreen lake. The width now averages about a quarter of a mile or rather more, with a depth of from 40 to 50 feet. The current runs at the rate of about 3 miles an hour in the middle, except at two very narrow parts where it is considerably greater. Owing, apparently, to the considerable depth of water across the greater part of the bed of the stream, strong eddies are found on both sides which greatly facilitate the upward navigation of this part of the river.

'The remarkably straight north-and-south stretch of the river is reported to stretch as far as Split lake. Its eastern bank consists

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[1] Geol. Surv., Canada, Report of Progress, 1877-78, pp. 19-20 CC.

almost entirely of drift clay, while gneiss is exposed nearly all along the west side.' . . . . 'Trap appears at the extremities of points on either side and in two or three small islands. The dolerite is divided by joints parallel to its course and is very friable. It is coarsely crystalline, and has a dark brown colour near the surface owing to the presence of oxide of iron, but some fresh fractures show a dark somewhat greenish-grey colour. In some parts, white calcspar and compact olive coloured serpentine are developed in thin sheets in the numerous longitudinal joints and also in the horizontal and vertical transverse partings, so that rectangular pieces of the dolerite, which crumble out, are completely encased in these minerals. Small streaks of magnetic iron, running parallel to the walls, are found in one part of the dyke. . . . .'

'In some places the gneiss immediately adjoining the dyke on either side has been altered and jointed parallel to the walls, by the action of the trap. . . . .' 'Both the gneiss and the harder points of the trap, forming its walls, are rounded and striated by glacial action.' . . . .

'At a point on the west side of the river 2 miles above the inlet of the lake, a great dyke makes its appearance, and is probably a part of the same one which crosses the stream 2 miles farther up, forming the Chain-of-Rocks. The dolerite is here of the same character, and contains the same peculiar serpentine as the dyke along the straight stretch of the river just described. Along the latter stretch and also along the shores of Sipiwesk lake and the river above it, dark grey, finely crystalline dolerite is frequently seen in the form of dykes of greater or less width and also as patches filling angles in the rocks of gneiss overlooking the water. On the sides of the straight stretch these dykes generally run parallel with the main one, but some of them follow the southwestward course of the stratification of the gneiss, and diminish in size in receding from the river as if they were offshoots from the great dyke.'[1]

Split lake and the river between Split lake and the sea were also explored by Dr. Bell, who thus describes the rocks encountered[2]:—

'Between the Grand rapid and the western part of Split lake the gneiss is partly reddish and partly grey and hornblendic. The strike varies in different places from S. 60° to S. 80° W. It is cut by a number of dykes of dark coloured diorite, some of which, just below the junction of Grass river, are very large. They have a general north and south trend. On the north side of Split lake, opposite the two inlets of the Nelson, the gneiss is cut by numerous dykes of all sizes and running in many directions. Below Chain-of-Rocks rapid on the northwest side of the river, dark grey quartzite and hornblendic schist occur, and also a dark green serpentinous looking rock with a somewhat schistose structure. The Burntwood river, a large stream, with turbid water like that of the Nelson, enters the western extremity of Split lake. On each side of the mouth of this river the rocks consist of quartzose, felsitic and hornblendic slates, running west-southwest, much cut up by trap dykes. At the Island of the Dead, in the entrance of the river, hornblendic schist is interstratified with ribboned quartzite, striking east and west. The rocks on some islands about a mile northeast of the western or principal inlet of the Nelson river, consist of dark bluish-green, hornblende and mica schist, interstratified with ribboned gneissic bands and with irregular layers of softer, light green schist, all much contorted. The rocks of the point between the Nelson and Burntwood rivers, and the islands for 2 miles to the northwest of it, may be considered as Huronian (Keewatin), but beyond this, in the same direction, they pass into gneiss, consisting of the hornblendic and micaceous layers, alternating with others of quartz.

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[1] Geol. Surv., Canada, Report of Progress, 1877-78, pp. 15-16 CC.

[2] Ibid. and Geol. Surv., Canada, Report of Progress, 1878-79, p. 27 C.

'Split lake runs east-northeast, and is about 25 miles long by 2 or 3 wide. The rocks along its northern shore consist of gneiss, which is generally of a hornblendic character, interstratified with quartzose layers. Towards the west end the strike is about east and west, but elsewhere it is much disturbed. Besides the rocks of Huronian character just described as occurring at this extremity of the lake, a green hornblendic rock, which was met with on an island near the east end, may be of the same age. What appears to be another limited area of Huronian (Keewatin) rocks in this part of the country is met with on the south side of Grass river where it joins the Nelson. Here at about half a mile west of the Grand Rapid portage, there is a ribboned, slaty, hornblendic rock, together with a coarse variety, and a dark grey quartzite, dipping S. 20° W. angle 60°. These are cut by a great diorite dyke, running north and south. Siliceous hornblende slates are found to the west of this, but at about 4 miles from Grand Rapid portage rusty quartzose gneiss, which is believed to be Laurentian, appears, dipping S. 40° E. angle 60°.'

The portion of the river between Split lake and the northern edge of the fossiliferous dolomites of the Hudson Bay basin, Dr. Bell reports,[1] is occupied by Laurentian gneisses and schists, except a short stretch of river at and below the lowest Gull rapid, where a small area of what appear to be Keewatin rocks occur.

'At a point on the north side about a mile below this rapid, a coarse grey mica schist, with strings and bunches of white quartz along the bedding, dips N. 15° E. angle 80°. Crossing the foot of the rapid itself is a band of fine-grained, massive mica-schist, passing into dark grey quartzite, ribboned with streaks of white quartz and no feldspar. The dip is N. 10° E. angle 80°. A finely crystallized diorite, probably forming part of a dyke, was observed at the sides of the rapid. The Laurentian gneiss in the section which has been indicated presents some variety in composition, colour, texture and in the character of its stratification.' . . . . 'Sometimes the gneiss passes into hornblende or mica schist. In a few places the latter is studded with garnets, and it generally contains veins of coarse, light coloured granite.'

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[1] Ibid.

Between Split lake and Gull lake the river is wide, and flows with a moderate current except just below Split lake, where there is an easy rapid about 2 miles long, and at about midway between the lakes, where two short rapids occur. The bordering country along this stretch is generally level, though an occasional ridge of clay gives to the surface a slightly undulating character. Gull lake is about 12 miles long and 4 wide, and contains a few islands. Biotite granite gneiss is the only rock exposed. Below Gull lake the river begins a rapid descent, and for the next 40 miles its course is broken by many falls and rapids.

The most westerly exposure of Palæozoic sediments noted by Dr. Bell occurs on the southeast side of the river, at the foot of Broad rapid, where a finely arenaceous, light bluish-grey dolomite outcrops. It holds fossils characteristic of the Winnipeg limestone, and is, therefore, of Ordovician age.

For 2 or 3 miles below the first exposure of limestone, gneisses occur in the bed of the river in low knolls.

Ledges of dolomite lying horizontal or gently undulating protrude from the clay banks here and there, down to the Third limestone rapid, where bluish-grey, drab and buff, somewhat arenaceous dolomite is exposed in horizontal beds. Beds of crumbling buff and greyish dolomite form a cliff 12 feet high at the second limestone rapid. They lie horizontally, but, a mile below, occur in gentle undulations. At the First limestone rapid, 8 miles below, 20 feet of buff coloured fossiliferous dolomite is exposed on both banks of the river. The lowest exposure of limestone found in place occurs 2 miles above Pakwahagan river, or 62 miles in a straight line from Beacon point. Between the limestone rapid referred to above and the lowest exposure outcrops occur here and there, and at one place 6 miles from the lowest ledge form a cliff rising 30 feet from the water.

"'At all the foregoing localities the rock has a yellowish-grey colour, is rather fine-grained, soft and generally earthy, although some of the beds appear to constitute a tolerably pure dolomite. It is thinly bedded, with the exception of a few bands, a foot or more in thickness, at the last locality. The only fossil observed was an obscure *pentamerus*, which was abundant in one of the beds, but none of the specimens were sufficiently well preserved to identify the species.'

For the lowest 60 miles the river flows in a valley excavated entirely in drift, and no exposures of the underlying rocks outcrop.

Of the lower portion of the river, Dr. Bell says:—

'The mouths of Hayes and Nelson rivers are separated from each other by a low tongue of land, called Beacon point. The shallowness of the water and the low, monotonous character of the shores everywhere in this vicinity renders it difficult to draw a definite line between land and water. Extensive shoals extend for miles out from the extremity of Beacon point and from the shores to the north and south of the estuaries of the two rivers. Owing to these circumstances the outline between the land and water is widely different at high and low tide. The difficulty of mapping the shore accurately is increased by the fact that the sea is receding at an appreciable rate, and also from the circumstance that the tides are of very irregular heights, owing to the shallowness of the water for long distances in all directions and the great effect which the winds consequently have in increasing and diminishing the rise and fall.

'The mouth of the Nelson river at high tide has a breadth of 6 or 7 miles opposite the extremity of Beacon point, but it contracts rapidly, having a trumpet-like outline, and for the first 10 miles up the width is from 3 to 4 miles. It continues to narrow gradually to Seal island at the head of tide water, or 24 miles from the extremity of Beacon point (at high tide), where it is only one mile and a half broad. Above this, it varies from half a mile to a mile and a half as far as we went (90 miles up).

'When the tide is out the greater part of the space between the banks in the estuary of the river is dry, and consists of a dreary stretch of mud-flats dotted with boulders, constituting a continuation of the shoals farther out. A narrow channel with a somewhat irregular depth of water winds down the centre of the estuary. From the soundings which I took, it appears to have an average depth of from 2 to 3 fathoms at low tide from a point abreast of Beacon point for about 20 miles up. At the mouth of the river the ordinary spring tides amount to about 12 feet, and the neap tide, from 3 to 5 fathoms, may be found throughout the whole distance.

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[1] Geol. Surv., Canada, Report of Progress, 1877-78, p. 12 CC.

'The shallowest part of the river which we sounded was abreast of Gillams and Seal islands, or just where the tide ends and the proper channel of the river begins. Here the water was only about 10 feet deep. But from this point upward, as far as we went, the average depth of the centre of the river was found to be 20 feet, and sometimes our soundings showed over 30 feet of water. In this section of the river the velocity of the centre of the stream varied from about 2 to 6 miles an hour, according to the experiments which were made with the submerged tops of spruce trees, in order to ascertain the rate, at least approximately. The swift parts are short, and the mean velocity may perhaps be taken at from 2½ to 3 miles per hour and the average width at three-fourths of a mile between the water margins.

'A short rapid occurs a few miles below the highest point to which we explored the river, but it does not appear too swift to be surmounted by streams. Above it the Indians report no obstruction for about 15 miles, when a cascade, called Limestone falls, is reached. The Nelson river may, therefore, be said to be navigable for river steamers to a distance of about 100 miles from the sea.

'The distance from York Factory to the extremity of Beacon point is about 5 miles. In going towards the latter the banks gradually diminish in elevation from 27 feet at York Factory to the level of high tide at Beacon point. They consist of stratified greyish clay combined with more or less fine sand. Below high tide the beach in the above interval consists of a muddy, bluish clay with rounded pebbles and some boulders, and contains marine shells which are tolerably plentiful. . . . . .

'As already stated, the shores about the mouth of Nelson river are very low and flat. Banks of clay, at first only a few feet high, begin to appear on both sides about 10 miles above the extremity of Beacon point, and, in ascending the river, the banks of clay on either side gradually rise till a point is reached about 54 miles, in a straight line, from Beacon point, where they are nearly 200 feet in height, and above this, as far as observed, they maintain about the same elevation either immediately overlooking the river or at a short distance back from it. A layer of peat, averaging about 4 feet in thickness, was observed almost everywhere at the top of the bank on either side and extending inland. At Flamborough head, a prominent point on the northwest side, 19 miles from Beacon point, the clay bank has attained a height of 126 feet. It consists of hard, gravelly, drift clay, with some boulders at the bottom, and drab coloured, stratified clay towards the top. At and near the top, marine shells are abundant.

'About 35 miles farther up, where the bank in the southeast side has reached its maximum height of nearly 200 feet, it consists entirely of thinly-stratified, yellowish-grey, fine, clayey sand or sandy clay, the thickest bed not exceeding 7 inches; while others are only an inch thick. The thicker and thinner beds alternate with great regularity in some portions of the cliff. In one place in this vicinity the whole depth of the deposit is seen in a perpendicular wall, which forms a favourite resort for great numbers of cliff swallows, their nests being built under the projecting edges of beds of hard, dry clay. Marine shells . . . . are washed out of this bank, large valves of *Saxicava rugosa* being the most common.'

'No islands occur in the estuary of the river, but from the head of tide, in the distance to which I ascended, upwards of twenty covered with timber were passed, besides a number of others on which only grass was growing. The wooded islands are comparatively high, while the grassy ones are low and flat, and are evidently swept over by the river ice when it breaks up in spring. From the Pakwahagan river (70 miles from Beacon point) upward wide flats, covered with good grass, occur here and there on both sides of the river. The grassy islands and flats probably owe their preservation to the underlying horizontal beds of dolomite, which prevent them from being worn away by the force of the ice.'

Burntwood River.

The Burntwood river for its whole course flows over Pre-Cambrian rocks. At its mouth, where, gradually occupying a wider valley it merges into the southwesterly bay of Split lake, the shores are made up of low rounded ledges of gneiss made up of contorted and broken bands of fine black biotite-hornblende gneiss enclosed in coarse white biotite gneiss. Similar gneisses are exposed as rounded knolls in the valley, wherever the river has washed away the clay which forms a thick mantle over this part of the region, up as far as the Elbow above Odei river. At the Elbow and at the rapids 2 miles above, a diabase or hornblendite made up, in many exposures, almost entirely of hornblende, cuts the biotite gneiss. A short distance farther up the river, rocks that seem to be variations of the hornblendite—red hornblende granites or granodiorites and gneisses—enclose blocks of the biotite gneiss. A similar complex of granitic and gneissic rocks occupies the river valley to Manazo falls with, along a stretch of 3 miles extending to within 2 miles of the fall, tongues of fine schists with the composition of diorites extending into the more granitoid gneisses from the southwest. These are cut by fine granites and quartz-porphyries, marginal phases probably of the hornblende granites, and seem to represent the frayed and tapering ends of the broader belt of Keewatin rocks that crosses Manazo brook at Pipe lake. Continuing up the river above Manazo fall, coarse white and fine black gneisses occur interbanded so as to present a stratiform appearance, the coarser white cutting, however, and enclosing as broken bands, the finer black. The dips vary from 45° to 90°, and the strike keeps a general northeasterly direction with many minor deflections to about the foot of Opegano lake. Along the lake the dips become lower, and above it the gneisses occur in low undulations or are horizontal. Many of the fine bands are highly garnetiferous, and hold crystals an inch or more in diameter.

The rock surfaces are all well glaciated, the striæ showing an ice-movement from the east.

This low undulating attitude is held by the gneisses occurring about Wekusko lake, where also the finer bands are garnetiferous, and up the river for several miles to beyond the Witego rapids. Approaching Threepoint lake, though the stratiform appearance is still marked, the dips are not so uniform and become, in places, as high as 80° and 90°. For 8 miles above Threepoint lake the rocks are mostly concealed by the clay cover; occasional exposures indicate that the underlying rock is a gneiss, poor in mica and in certain bands garnetiferous. In some of the ledges exposed along this stretch, the gneiss has an even grain and would make a good quarry stone.

Between Wekusko lake and Threepoint lake the striæ are lighter than they are to the east and west, and their direction is about southwest. Banded, more quartzose biotite gneisses are exposed in numerous ledges along the stretch of river below Wimapedi brook and above it to Moosenose fall. The rocks dip at high angles and the surfaces are heavily glaciated, the originally rounded surfaces of the ledges being planed off flat as though with a smoothing plane. Striæ show an ice-movement S. 20° W.; occasional, lighter striæ have a direction S. 45° W. Quartzose biotite gneiss, not so conspicuously banded and with the biotite content small, is exposed in many places in the river bed, and forms low ridges along the banks to above Bushy brook. The ledges for a few miles along this part of the river valley and beyond, at Apisk rapid, show very little evidence of glaciation; the surfaces are unplaned and rough, little cliff faces are common, and rotted rock covers some of the ledges.

Westward to Burntwood lake and about the shores of the lake the gneiss has a stratiform appearance from the occurrence in coarser gneiss of bands of fine black gneiss or schist. Below Burntwood lake the hills are higher and are bare, the clay cover being restricted to surfaces under 30 feet above the river. Above Burntwood lake the river is continued as File river, flowing into the lake from the south. Along File river the gneisses are very markedly banded, and have a stratiform appearance; the direction of dip is very uniform about N. 80° E., the strike following the same direction as the river valley. For a distance of 5 miles below Limestone Point lake the dips on the right bank are at higher angles than they are on the left bank, and probably indicate an overturned fold or perhaps a fault along which the river flows. Above Limestone Point lake also the strike accords with the river valley in direction, and the dips are at higher angles on the right bank than on the left.

On Limestone Point lake occurs a small outlier of light, yellow-buff magnesian limestone, containing obscure organic remains and resembling lithologically the limestone of Trenton age to the south, from which it is separated by a gap of 25 miles. The outlier is, in the main, flat-bedded or gently undulating, but in places is very sharply folded and crumpled.

Continuing up the river towards File lake the gneisses have a stratiform appearance owing to the occurrence in the coarse biotite white gneiss, of hard bands of fine black hornblende gneiss or schist, which gradually increase in volume in proportion to the coarse gneiss as the lake is approached. Where the rocks are horizontal or nearly so the semblance of the interbanding to stratification is strong, though the coarse gneiss plainly cuts the schists. There is a gradual passage from coarse biotite gneisses with narrow enclosed bands of amphibolite through a zone in which the schists occur in increasingly broader bands to an area—surrounding File lake and extending southerly to Reed lake—where diorites and amphibolites only are seen.

Churchill River.

Throughout almost the whole of its course within the area mapped the Churchill river flows over rocks of the Pre-Cambrian complex; the exception is where, near its mouth, the river enters the Hudson Bay Palæozoic basin and flows for a distance of about 150 miles over Ordovician limestone. The highest point on the river reached by the writer was the head of Rock lake. The part between the head of Rock lake and the western boundary of the map-sheet is thus described by T. Fawcett, D.L.S., who made a survey of the river in the year 1888:—

'As we pass easterly from the head of Bear Island lake the green timber becomes more scarce, the banks rise higher and are in many places rocky and bare. The rocks are gneissoid, the strike being almost uniformly a few degrees east of north, while the dip is variable. In many places magnetic iron ore is present in the rocks, causing a variation in the declination of the needle sometimes amounting to 10°. Sometimes for 4 or 5 stations in succession the variation of the needle would be 4 or 5 degrees too small and then perhaps for a similar distance, too large. Even in sandy places where the rocks do not appear at the surface there is this variation. The dip and force seem to be much less affected by local causes than the declination. At the northwest angle of Black Bear Island lake a stream called Whitefish river flows in from the north. This is the stream mentioned above which is reached by the Indians with canoes from Pine river via a series of lakes. In crossing Black Bear Island lake and following the boat route it is impossible to determine which is mainland and which is island, the entire body of water being made up of narrow channels and deep bays. In crossing the lake we ran two rapids. It was something new in our experience to find rapids in the middle of a lake. It would take a party an entire season to determine the extent, outlines, and islands of the so-called Black Bear island lake.

'Thirty-six miles from the commencement of the lake we reached the outlet where there is a fall of 8 feet, passed by Birch portage on the right bank. Near the northeast end of the lake a second stream comes in from the north, also called Whitefish river. By travelling up this stream one day, in canoes, a lake called Whitefish lake is reached. A mile from the foot of Birch portage we came to Trout lake which is followed for 10 miles to Trout falls. About a mile and a half south of Trout falls a southerly branch forks off and joins the main stream again in Dead lake. Near the head of Trout falls a stream comes in from the north, called Trout river, and this expands at a short distance up into another part of Trout lake, larger in extent than that crossed in travelling through the country. After passing the Trout falls, in a distance of 7 miles there are that number of rapids, 3 of which are passed by portages, but may be run with canoes by persons acquainted with the river. At the foot of the rapids and where the southerly branch comes in from Trout lake, the stream expands into Dead lake. Some spruce and pine are seen in this part, but no timber suitable for merchandise. Poplar and birch form the prevailing timber. On many of the rocky hills the timber has been burnt and the bare rocks stand out prominently.

'Passing down stream from the outlet of Dead lake we came across a series of rapids known as the Devil's rapids and Big Devil's portage. Most of these rapids are dangerous in consequence of boulders, but are all usually run except at Big Devil's portage. At the foot of these rapids the stream expands into a lake called Devil's lake which terminates at Otter portage where the water descends some 20 feet to Otter lake. This rapid is passed by a portage on the left bank. Following Otter lake some 13 miles we come to Rock portage, better known as the Mountain and Stony Mountain portages. This latter brings us to Rock lake[1] which extends to Stanley, where a Church of England mission and a Hudson's Bay Company's post are located, at the south end of the lake. The Company call their post Rapid river, but Rapid river proper joins the Churchill 13 miles farther east in Rapid River lake. Near the mouth of Rapid river on that stream is a fall of over 30 feet. There is not much arable land in the vicinity of Rock lake, but where there is surface soil it is generally a clayey loam of good quality. Mr. Moberly, in charge of the Hudson's Bay Company's post here, kindly supplied us with vegetables from his garden. There had been no frost yet up to the middle of September to cut down the potato vines which were as green as during the earlier parts of summer. This locality seems to be entirely free from summer frosts.'[2]

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[1] See Plate XII.

[2] T. Fawcett, D.L.S., Annual Report, Dept. of Interior 1888, pp. 79-80.

About the shores of Rock lake (Plate XII) are banded, coarse and fine gneisses dipping southwest at angles varying from very low to 70°, and in places lying quite flat or gently undulating. The fine gneiss is a well foliated, nearly black, hornblende gneiss or schist. It occurs in irregular bands in the coarse white biotite gneiss and is cut by it. Both are cut by later intrusions of coarse red pegmatite. In certain bands the fine dark gneiss is spotted with large crystals of feldspar and in other bands with garnets. Along the western shores of the lake and of Guncoat bay a series of fine gneisses and hornblende schists, similar to those of the western part of Lac LaRonge, dip northwest at high angles. Like the Lac LaRonge rocks, these gneisses are in certain belts heavily mineralized with iron pyrites.

Below Stanley and continuing past Grave rapids and Grave lake, similar fine hornblende gneisses with interbanded fine, hard, reddish diorite gneisses occupy the shores dipping northwest at angles varying from 45° to 80°. These interbanded schists and fine gneisses form a broad belt or series of belts coming up from the south and terminating northerly beyond the river valley; one belt bends to the east, and in it the river has its channel easterly to the mouth of Reindeer river, where the belt, swinging to the north, is followed by the valley of Reindeer river. Lithologically the rocks of these belts resemble in places both the green schist member of the Keewatin and the gneisses of the Grenville series. In them a band of white crystalline limestone was traced along the left bank of Rapid river for a distance of 5½ miles, striking northeasterly towards the Churchill river. In the hurried examination of the shores of the Churchill the band was not seen, but Dowling[1] records the occurrence of crystalline limestone on the Churchill in this vicinity—without doubt a continuation of the same belt.

At Pine portage a bright red biotite granite, which is gneissic in places, cuts the gneisses and forms most of the south shore of Rapid River lake. The north shore of the lake, between the bands of fine gneiss and schist, is occupied by coarse white biotite gneiss, with bands of hornblende schist, which, though they have the appearance of being interlaminated with the coarse gneisses, are cut by them. The whole series of gneisses and schists are cut by many dykes of red pegmatite which are probably connected with the intru-

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[1] Annual Rep. G. S. C., Vol. VIII, p. 100 D.

PLATE XII.

22106—p. 82.

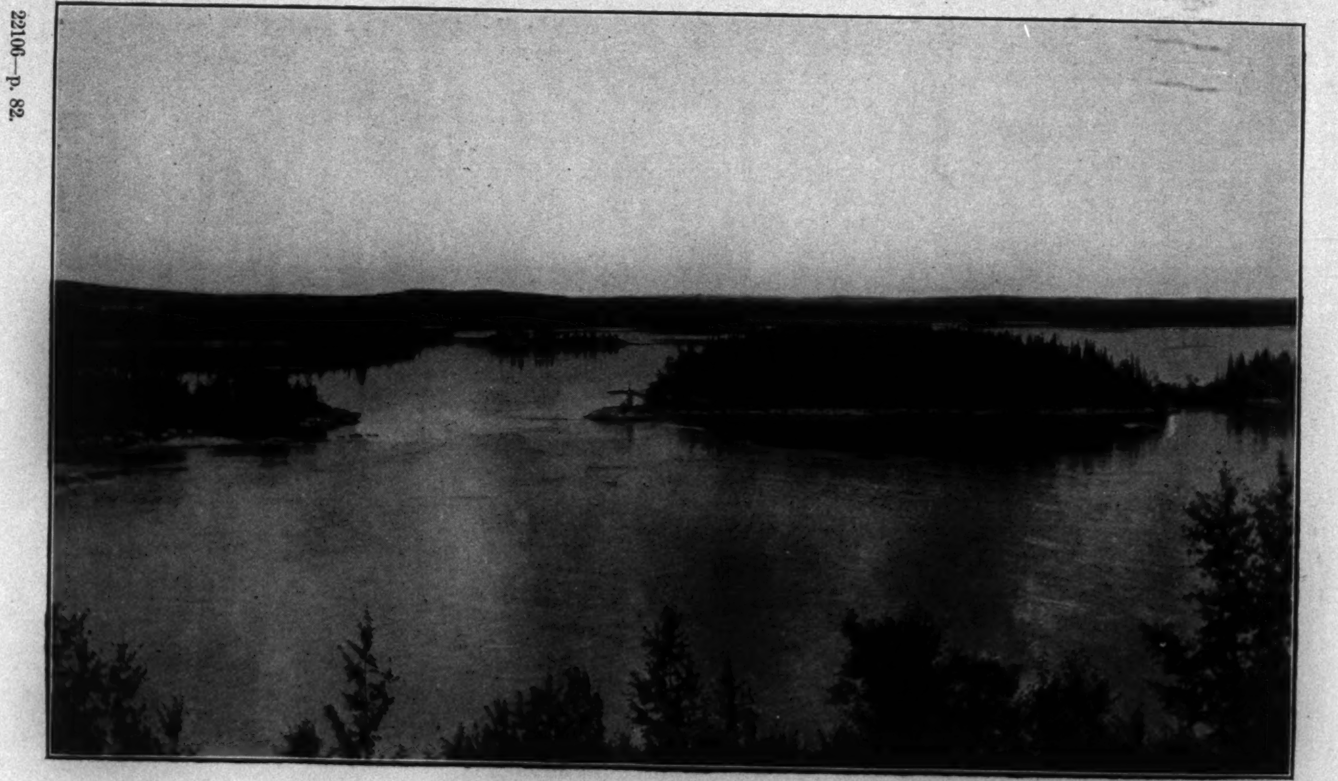

Photo by W. McInnes, 1910.

Rock lake, an expansion of Churchill river.

sion of red granite. Below Pine portage the strike swings somewhat abruptly to the east, and along Drinking lake banded, quartzose, biotite gneisses strike with the course of the lake. At Keg portage and at Grand rapids a mile below, the finely micaceous, fine, black hornblende gneisses occur as broad bands, in places quite chloritic and in places weathering rotten and rusty. The bands, like the narrower bands above, though they have an appearance of interlamination with the coarser gneiss, are intruded by them. Fine, banded, dark biotite gneisses occur along Island lake to Frog portage, where hard, quartzose, banded, biotite granite gneisses form the low barrier over which the water of the Churchill spills in periods of flood and flows south to the Saskatchewan.

Along the northeasterly trending stretch between Frog portage and Kettle fall the river follows a belt of fine, black hornblende biotite gneiss which is schist-like in certain layers and invaded at intervals by coarse white gneiss in the form of sheets or sills. Contorted gneisses of similar character outcrop at the mouth of Reindeer river and continue down the river through Wintego lake and rapids. The fine, black gneisses or schists are almost continuously exposed along this portion of the river; in some layers they are garnetiferous and in other layers show distorted crystals of feldspar. They lie at all angles of dip and, at the rapids, are horizontal. The invasions of coarse white gneiss are few, and preserve the sill-like or sheet-like character so often noted in them elsewhere.

Down through Pita lake and below it the coarse white gneiss is in larger proportion; it, in all cases, cuts the schists, but the two present, especially where they lie at low angles of dip, as in most cases along this part of the river they do, an appearance of stratification. On down past the mouth of Nemei river the relationship continues the same, and the semblance to stratification is, in places, very marked. Below the mouth of Nemei river the fine, black gneisses are much contorted, and are cut by many veins, sheets, and irregular masses of coarse white gneiss, and both are cut by dykes of pegmatite. Similar fine black gneisses, with coarse white preserving towards it the same relationship, occur all along the northerly-trending section of the river to the elbow at the mouth of Loon river. About Sisip lake and down the river to Pakkatawagan, there is the same stratiform interbanding of the two kinds of gneiss, and the finer black has many crystals of garnet in certain bands. The coarser white cuts the finer black, generally in broad bands but in places in masses of irregular shape. There is no change in the character of the rocks exposed along the shores down to Nelson lake. Bands in the fine gneiss all along from the mouth of Loon river to Nelson lake are abundantly garnetiferous.

Below Nelson lake the gneisses, though banded, have not the strongly stratiform appearance that characterizes them above that lake. A red granite, in places quite gneissic in structure, cuts fine black gneiss and is interbanded with it so as to produce a fine, hard, banded red and black or dark grey gneiss, the grey gneiss having the composition of a quartz-diorite; in thin section it is seen to be 'a coarse grained, holocrystalline rock containing plagioclase (rather basic), quartz, green hornblende, and biotite; the ferro-magnesian minerals making up approximately 30 per cent of the rock, and the quartz in subordinate quality.'

Down past Nishwustia rapids banded, fine, hard gneisses are the prevailing rocks exposed. They are cut by dykes of red pegmatite which are probably connected with a large area of red biotite granite and granite gneiss which occurs in the vicinity. A quartz-diorite of massive character and dark colour is exposed for several miles along the shores. It seems to merge, on the one hand, into a fine black gneiss or schist not distinguishable from the fine bands in the gneiss, and on the other, into a coarse red granitoid gneiss. Examined in thin section this rock was found to have a 'coarse grained granitoid texture and to contain quartz (abundant), plagioclase (albite to andesine), orthoclase, microcline, brown biotite, and titaniferous magnetite (altered to leucoxene).

The relationship between the gneisses, granites, and diorites exposed along this portion of the river was not plain. Much of the country is hidden under a cover of friable lacustrine clay, through which along the shore of Opachuanau lake, ledges and sharply angular blocks of red granite protrude. Many of the ledges where they emerge from the clay cover show fresh-fractured surfaces.

Southern Indian Lake.

Much of the northern and western portion of Southern Indian lake is underlain by interlaminated coarse white biotite gneiss and fine black gneiss, generally an amphibolite but in many cases having biotite mica as a plentiful constituent. Though these rocks exhibit strongly the appearance of stratification, the coarse gneiss is the

PLATE XIII.

22106—p. 84.

Photo by W. McInnes, 1910.

Pseudo-conglomerate (Pre-Cambrian), Southern Indian lake.

younger of the two and in every case bears to the finer the relation of an intrusive body.

On the southern and eastern shores the exposures, although they have the appearance of gneisses, include, like the rocks of Churchill river just above, of which they are in part a continuation, intrusions of several different ages very intricately mingled. Many have the composition of granodiorites and quartz-diorite gneisses, and others of alkali granites. Nearly all are quite well foliated and many are finely so, and might be described as very fine gneisses or schists.

An interesting series of interbanded fine gneisses occur about half-way up the east shore. They have very much the appearance of a stratified series, and include beds which have a somewhat close resemblance to conglomerates of sedimentary origin, though, with little doubt, they have originated from the stretching and sundering of banded gneisses. The enclosed pieces are ovoid or, in places, nearly round in shape, and are nearly all derived from fine reddish gneisses, but a few are of glassy quartz resembling vein quartz (Plate XIII). Bands in the gneiss in the neighbourhood are quite similar to the material of the gneissic pebbles, and little lenticular veins of quartz in the same rocks resemble the quartz pebbles. Associated with the pseudo-conglomerates and, like them, folded in a somewhat intricate manner, are fine, banded gneisses and hornblende schists, the schists having the composition of quartz-diorites. The examination of thin sections of these rocks afforded no evidence that they were of sedimentary origin. The material of the matrix enclosing the pebbles has a fine-grained holocrystalline structure and seems to be an aplitic phase of a biotite, alkali granite. Mr. Reinecke describes it as made up of 'quartz, microcline, albite, probably orthoclase, biotite, phlogopite, and magnetite. The constituent crystals of quartz and feldspar have closely interlocking edges; they show no sharp crystal faces. In places magnetite has been altered to hematite and feldspar to kaolin and muscovite (sericite). Biotite and magnetite do not take up more than 5 per cent of the volume. The rock is decidedly acid and alkaline. Biotites show parallel orientation; quartz show slight strain; quartz veins are oriented in the same direction as the elongation of the biotites.'

About the central part of the lake and on the bays extending to the south, the land is covered to a considerable depth by deposits of clay, which are evidently continuous with the extensive area of lacustrine clays to the south. The east shore, north of the point of outflow of the river, is characterized by extensive deposits of sand in the form of plateaus 75 feet above lake level, and by irregular hills and dunes of loose, shifting sand. These deposits probably represent the marginal accumulations of the glacial lake before referred to, in which was laid down the thick mantle of clay which covers so much of the land to the south.

Hayes River.

Hayes river, forming, as it did for many years, the main route to the interior from Hudson bay, was traversed by many of the early explorers, some of whom in their journals give brief notes upon the rocks encountered. In later years members of the staff of the Geological Survey have passed over the route, and the following description is compiled mainly from their reports.

The part of the route extending from the Nelson across to Knee lake and down Hayes river to the Rock is briefly described by R. W. Brock from observations made during the trip to Hudson bay of His Excellency Earl Grey in the summer of 1910.

[1] "From Lake Winnipeg to Hairy lake, on the Echimamish, the rocks are the grey granite and gneiss cut by red granite dykes and pegmatites. At the inlet of Hairy lake, on the south shore, the rock is the coarse red biotite granite, cutting a coarse feldspathic rock that appears to be anorthosite. The latter rock consists principally of feldspar (labradorite) in square or rounded crystals, about which are wrapped thin, long augite crystals, giving it the appearance of leopard rock. Other facies of this rock are white, like quartzite, but made up of long feldspar crystals with a square cross-section. The red granite, and probably the anorthosite also, holds inclusions of large size—100 feet or greater—of a nacreous mica-schist and of the coarse grey gneiss.

'On the Echimamish about 8 miles above Hairy lake the rocks supposed to be Keewatin first made their appearance. The first exposure seen was a banded quartzose schist standing on edge. Its general appearance is suggestive of some of the Keewatin iron-formation rocks. A similar rock was seen at the forks of the creek. At the first dam a tuff-like rock, containing feldspar grains, and slaty rocks that might be ash beds, are encountered. At the second dam is a somewhat massive chloritic schist with coarse mica, and quartzose schists. The dip of the rocks appears to be vertical. Veinlets of reddish, smoky quartz occur in all these rocks. At the third dam coarse grey gneiss reappears, followed by red granite. At the Painted Rock portage the gneiss is well banded; dark bands of augen gneiss alternate with cherty quartz, or pegmatite bands. Biotite and hornblende schist bands also occur. A small dyke of lamprophyre cuts this rock. The chert and hornblende schist resembles iron formation, but the gneiss bands, which are from half an inch to 3 inches wide, form the bulk of the rock. Granite and gneisses continue down the Hayes river past Robinson portage to the half-mile portage by which the canoe route leaves the river. On this portage is a dark hornblende schist, somewhat contorted and faulted, and seamed with quartz veinlets and pegmatite and aplite dykes. Across the lake from the east end of the portage is a well jointed phyllite. These rocks continue on the canoe route for about 5 miles, when the Laurentian granite and gneiss come in, and through Pine and Windy lakes and the first 5 miles of Oxford lake only granite and gneiss were seen. At the south point of the west bay of Oxford lake the gneiss is cut by a 20 foot lamprophyre dyke. An island about 2 miles west of Sevenmile point is composed of diorite or diabase, somewhat squeezed, and in places epidotized and showing the pillow structure that is common in Keewatin greenstones. The feldspar and coloured constituent are, however, still distinct.

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[1] Geol. Surv., Dept. of Mines, Canada, Summary Report 1910, pp. 18–20.

'At the first portage above Trout falls[1] is a greyish porphyritic rock with feldspar phenocrysts one-half inch long. At Trout falls is a micaceous schistose rock with small feldspars. It resembles a hornfels, but is almost certainly a squeezed igneous rock. Bands and small lenses of a gabbroidal rock are included in it, and it is veined by somewhat rusty, watery quartz.

'At the entrance to Knee lake a disturbance of the compass was noticeable, due no doubt to magnetite on the south side of the inlet, which Bell describes as "interstratified with grey siliceous and micaceous schists running about east and west." As we sailed down this part of the lake no opportunity was presented of personally examining these rocks. Through the glass the rocks appeared to be mainly greenstone or massive schist with some quartz veins. At the beginning of the Narrows the rock is a schist with greenish, cherty "eyes," varying from one-fourth of an inch to several feet long. They resemble pebbles somewhat, but are evidently the remnants of bands of chert, broken by pressure. Inland is a massive greenstone showing pillow structure, with calcite filling some of the cracks.

'Near the end of the Narrows the rock is a green sericite schist with lenticles of calcite and dolomite, which on weathering give the rock a pitted surface. It resembles a contact metamorphosed limestone.

'In the Narrows a small island which I did not see, called Magnetite island, is reported by Richardson to consist of "mica slate highly impregnated with magnetite, iron ore, and having its thin layers impregnated with layers of that mineral." Bell describes it as consisting of "fine-grained magnetic iron in thin layers, interlaminated with others of quartzite and mica schist. The rock is twisted and corrugated and breaks with a splinty fracture."

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[1] See Plate XIV.

'In the lower expansion of Knee lake the rock is a greenstone, probably diabase, squeezed and in some places epidotized with a well marked pillow structure and cut by quartz veins and dykes of syenite porphyry. On the islands near the lower end of the lake the rock is a mica schist with calcite and dolomite bands cut by some fair sized quartz veins.

'These supposed Keewatin rocks continue for a short distance below the lake. Here the grey gneiss reappears and continues to below the Rock, below which only drift is exposed.

'This band of Keewatin rocks, it will be noted, extends with a few intermissions from a short distance up the Echimamish to below Knee lake. Similar rocks are mapped by Tyrrell on Pipestone and Cross lake on the Nelson, and it seems probable that they belong to the same band.

'The rocks seen by the writer had a marked resemblance to the Keewatin, and so far as relationships were observed, they were also suggestive of this. The cherty masses seen strongly resembled those of the "iron ore formation" found in the Keewatin of the Lake Superior district. The descriptions given by Richardson and Bell of the occurrence of magnetite are also suggestive of "iron ore formation."

'No minerals of economic importance were observed, but the Keewatin and Huronian belts are worth prospecting. It is in these that the Sudbury, Cobalt, Porcupine, and other camps of northern Ontario occur. The quartz veins seen were "hungry," but it is encouraging to find quartz so common, and promising veins might be found by prospecting.'

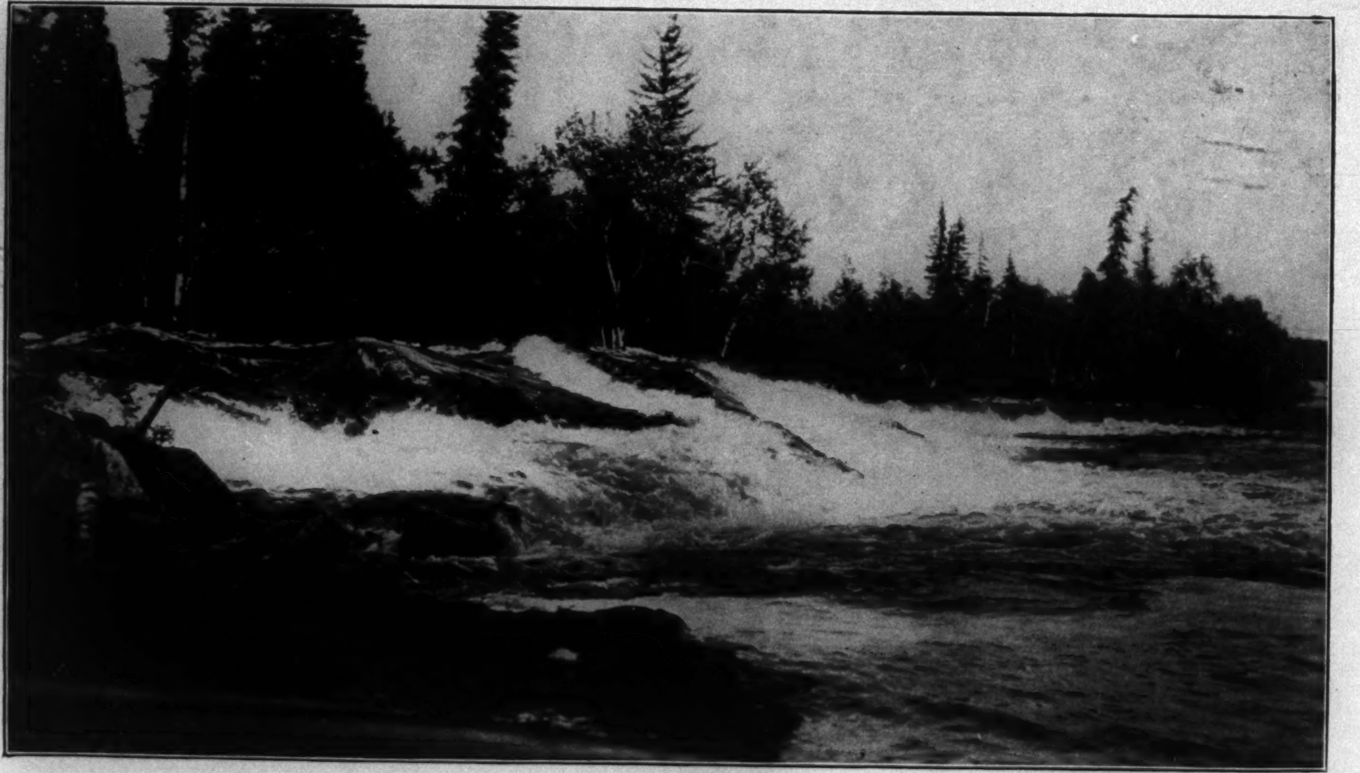
'Mr. J. B. Tyrrell reports arsenical pyrites and copper pyrites in the Pipestone Lake area on the Nelson river, and a mica deposit of possible commercial value on Cross lake.

'Mr. Wm. Ogilvie, of the Department of the Interior, has informed me that galena carrying 25 ounces of silver to the ton has been found on a lake north of Nelson House near the divide between Burntwood and Churchill rivers.

'Iron deposits of importance may occur in the bands of iron ore formations.

'It is perhaps worth noting that among the boulders from the drift along the lower part of the river banded jasper hematite ore, like that of the Lake Superior deposits, occurs, also basalts and melaphyres like the Lake Superior copper rocks, together with beautiful porphyries and perthite. It is difficult to say where the boulders came from, as both westerly flowing and southeasterly flowing glaciers passed over this section, but these rocks might be almost local and perhaps underlie the Silurian. They are known to occur

PLATE XIV.



Trout fall, above Knee lake, Hayes river.

Photo by R. W. Brock, 1910

22106—p. 88.

PLATE XV.

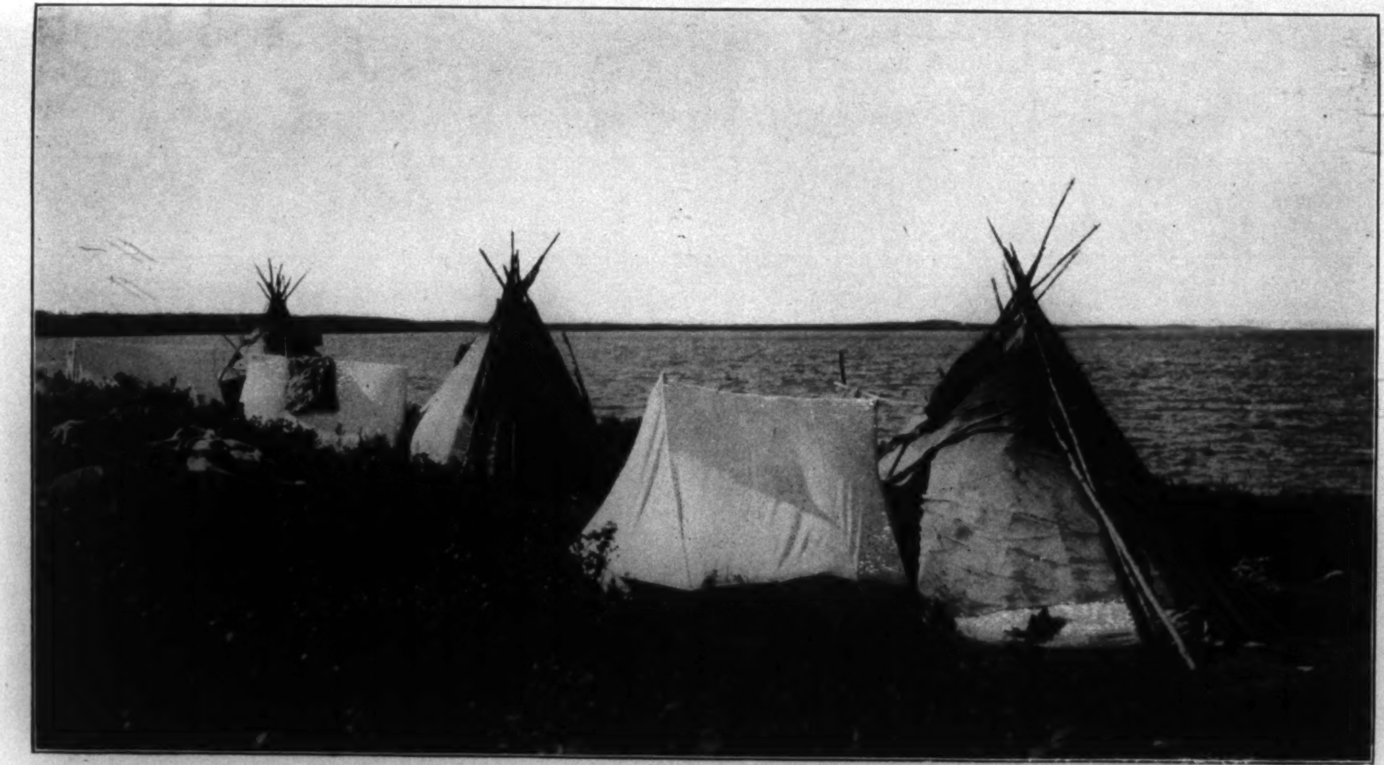


Photo by R. W. Brock, 1910.

Cree Indian camp, Knee lake.

on the east coast of Hudson bay, also south of James bay, and it seems not improbable that they also fringe the west coast; in other words, that the Huronian forms a big basin in which the bay rests, in much the same way as it does about Lake Superior. Wherever we landed in the north country to Port Burwell, iron ore formation rocks were noticeable, so that its distribution would seem to be widespread.'

'Hudson bay has a length of about 900 miles and a maximum width of 600 miles. The east coast, which is composed of Pre-Cambrian rocks, is rugged, but the west coast from the mouth of Rupert river at the head of James bay, to the mouth of Churchill is low and flat, being underlain by flat-lying Palæozoic rocks. At ebb tide wide, often boulder strewn, mud flats are exposed. From Churchill north the Pre-Cambrian rocks obtain and the coast becomes rugged.

'York Factory is situated on the narrow point of land which lies between the mouths of Hayes and Nelson rivers. Both have funnel-shaped mouths opening northeastward, the Hayes being about 3 miles across and the Nelson about 15, but rapidly narrowing up stream.

'The sediment brought down by the rivers, particularly by the Nelson, has silted up the mouths of the rivers and formed a huge bar, that extends for many miles out to sea. As the Nelson is one of the large rivers of the world, it may be expected to maintain a well marked channel through the bar, but the Hayes is rapidly silting up with the material discharged by the Nelson.

'Fort Churchill is situated at the mouth of Churchill river on a tidal lagoon enclosed by rock ridges, that form a fine, well protected, though somewhat circumscribed, natural harbour. It lies within the barren grounds, but only a short distance beyond the northern limit of the forest. On both sides, a few feet above high tide, are dry, sandy flats, parts of an old raised beach. Several other gravel beaches are found on the sides of the hills and up to their summits. These raised beaches are also marked features along Hudson strait and all the way down the Labrador coast. The rocky ridges that enclose the lagoon rise to heights of from 60 to 100 feet, and are composed of a massive, coarse-grained, feldspathic, arkose quartzite. In the quartzite are a few irregular quartz veins up to a foot in width and a few small pegmatite dykes. From the physiography it is impossible to say whether the bottom of the lagoon has a thick mantle of gravel and thus would be easy to deepen by dredging, or whether it has practically a rock bottom; but it is quite possible that it has the former.'

Hayes river, below the foot of Knee lake, after a course of about 10 miles broken by several rapids, expands to form a long, narrow lake known as Swampy lake. Below for 19 miles the river flows through a labyrinth of small islands. The bed of the river and most of the islands are formed of angular blocks of gneiss, and ledges of gneiss outcrop at many of the rapids. From the foot of this stretch and extending down the river, clay banks appear on both sides of the river.

[1] 'Brassy hill . . . . the only hill known to exist in the whole region, is a remarkable, isolated mound of gravelly earth 392 feet in height. Its summit lies three-quarters of a mile east from the river and 4 or 5 miles beyond the lower termination of the labyrinth of islands.

'The clay banks are about 30 feet high where they begin, but, in descending the river, they increase by degrees to 100 feet in the neighbourhood of the Rock and then gradually diminish to 60 feet at Fox river. An average section of these banks in the interval, consists of 50 feet of hard, bluish or yellowish-grey drift clay, in which the pebbles are not conspicuous as components and boulders are rare, overlaid by 20 or 30 feet of stratified bluish clay with occasional boulders. In the last 9 miles before reaching Fox river the river winds, with great regularity of distance from bend to bend, between banks about 80 feet high and three-fourths of a mile apart. They consist of 40 to 50 feet of drift at the base and 20 to 30 feet of stratified bluish clay, or the same thickness of yellowish-brown, gravelly earth at the top, with occasionally a bed of gravel between them.

'From Brassy hill to Fox river, few islands occur in the river, which has an average width of only about 2 chains. Several rapids and chutes over ledges of gneiss underlying the clays occur in the first 13 miles below Brassy hill. The last one, at the end of the above distance, or 109 miles above York Factory, is called the Rock, from a considerable exposure here of dark grey, rather coarse gneiss. Gneiss was last seen in the bed of the river about 6 miles below the Rock, and it is supposed that the Palæozoic basin of Hudson bay is entered upon in this neighbourhood.

'The section of the route between Fox river, from the left at 75 miles from York Factory, and the Shamattawan from the right at 50 miles from the same point, has a width of about 3 chains. Clay banks, with an average height of 70 feet, are continuous on both sides of the river, and marine shells, chiefly *Saxicava rugosa*, derived from the upper beds were noticed all along this section of the river. . . . .

'Along the stream above described, from the Rock downwards, islands are almost entirely absent, until the head of tide-water is reached. Here three wooded islands occur in succession, and below them is a chain of low islands near the southeast side, covered with grass and affording abundance of hay for the cattle kept at York Factory.

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[1] Geol. Surv., Canada, Report of Progress, 1877-78, Part CC.

'The unaltered Palæozoic limestones are not exposed on any part of the above route, and their existence under the drift from near the Rock to York Factory is only inferred from the prevalence of limestone debris in the shingle, from the absence of older metamorphic rocks, and from the general character of the country, which resembles that along the lower part of the Nelson river, where these rocks actually crop out.'

Soundings in Hayes and Nelson Rivers.

Joseph Robson,[1] surveyor to the Hudson's Bay Company, made a series of soundings in Nelson harbour about the middle of the eighteenth century. The book in which they are published is out of print and rare; the records of these soundings are republished for comparison with soundings now being made by the Hydrographic Surveys Branch, since the comparison may be of value in establishing the rate at which silting is taking place and as evidence for or against the reported rising of the land about Hudson bay within the historic period.

'Monday, the 15th of July, 1745, fifteen minutes past seven in the morning, set sail in the Factory's long-boat, in company with Captain Fowler, from on board the Sea-horse pink, then lying in Five-fathom-hole, to sound and discover Port Nelson river. At thirty-eight minutes past seven, abreast of the beacon that stands at Five-fathom-hole, the water fallen one foot; a neap tide, wind N.E. a fresh gale; course from the beacon S.E. by E, one mile and a quarter; sounded from four fathom and a half to eleven feet; the beacon bore W.N.W., distance one mile and a half. Nine minutes past eight, altered our course, steered N.N.W. one mile and a quarter, sounded from eleven feet to two fathom, being across the channel that leads into Five-fathom-hole in Hayes river; this channel is of considerable breadth. At this time of tide we found two fathom and a half in the best or deepest of the channel and close to the north sand sounded three fathom and a half; ship and beacon in our bearing S.W. half W. distance one mile. Twenty-one minutes past eight, altered our course, steered S.E. by E. three miles, crossing the Fair-way into Hayes' river; sounded from two fathom to six feet; sounded two fathom and a half in the best of the channel; the beacon bore W. by N. distance three miles and a half. Four minutes past nine, altered our course, steered N.N.W. two miles and a quarter, sounded from six fathom to nine feet, being from side to side of the Fair-way into Hayes' river; found a considerable breadth of channel, where was two and a half to two and a quarter fathom at that time of tide; the beacon bore W.S.W. distance three miles. Twenty-nine minutes past nine, altered our course, steered S.E. by E. one mile and a quarter; sounded from nine to ten feet across the entrance of Hayes river; sounded two and a half and two and a quarter fathom in the best of the channel; beacon bore W. distance four miles. Forty-seven minutes past nine, altered our course, steered N.N.W. five miles, sounded from ten feet to five fathoms and three-quarters in this course. At sixteen minutes past ten, we had three fathom water; being on the north side of the sand that parts the Fairway into the two rivers Nelson and Hayes, from whence we had three fathom water; the ship in Five-fathom-hole, bore S.W. half W. distance five miles, but at the end of this course where we had five fathom and three-quarters, the ship bore S.S.W. distance six miles. Sixteen minutes past eleven, altered our course, steered N.W. one mile, sounded from five three-quarters to six fathom; the ship bore S. by W. distance seven miles. Thirty-three minutes past eleven, altered our course, steered W. four miles, tried the tide of ebb by bringing the Jolly boat to a grapnel, the tide run E. one knot and a half. At twelve hove the logg; the boat's way was two knots and a half; four knots run off the reel; sounded from six fathom to two and a half; the ship bore S. by E. distance eight miles and a half. At one altered our course; steered S.W. half a mile, to try to deepen our water; it now began to be a thick fog, the wind blowing fresh at N.E.; sounded from two fathom and a half to eleven feet. Thirty minutes past one, altered our course, steered N.W. two miles and a half; sounded from eleven feet to four fathom and three-quarters. Forty-five minutes past one, altered our course, steered W. two miles, sounded from four fathom and three quarters to two and a half. Eleven minutes past two, altered our course, steered S.W. one mile, sounded from two fathom and a quarter to eleven feet. Twenty-six minutes past two, altered our course, steered N.W. one furlong, sounded from eleven feet to eight feet. Twenty-nine minutes past two, altered our course, steered S. half a mile, sounded from eight feet to four feet; we had now a very thick fog, a fresh gale and a great sea. Thirty-nine minutes past two, altered our course, steered S.W. four miles, sounded from four feet (the next cast seven feet, the second cast seven fathom, the third cast eight fathom and a half) to four fathom; the fog being gone we found we were four or five miles within the river. Fifteen minutes past three, altered our course, steered S. two miles to try the channel, sounded from four fathom to six feet. Forty-five minutes past three, steered right across the river one mile and a half, from six feet on south side, to six feet on north side; found the channel half a mile broad, from three to three fathom; in the middle of the channel there is four fathom and a half, a soft clay bottom; we run up this channel one mile and a half, sounded from four fathom and a half to two fathom and a half, then three fathom; presently we were in five fathom; then six fathom; we were now abreast of the first remarkable gully near one mile and a half above the foot of the high land; from five fathom we sounded very uneven soundings; one cast two fathom, the next four or five feet, then three feet in the middle of the river; here we were upon the middle ground, the channel being near the north and south sides of the river; then we run near the north shore; sounded from four feet to two fathom several times. When we got to Flamborough head, the soundings were more regular. Three minutes past six, we passed Flamborough head, sounded from ten feet to three fathom and a quarter, and from three fathom and a quarter to two fathom; we had these soundings near a mile; now it was first water flood. From these good soundings to Seal island we sounded twice from two fathom to six feet. Within three or four hundred yards of Seal island, we sounded twice from two fathom to six feet. Within three or four hundred yards of Seal island the channel is very shallow; close to the north end of Seal island, there is from two to three fathom water; neap tides flow here about four feet, spring tides about eight feet. Seal island is about three miles and a half above Flamborough head by computation. Thirty minutes past seven, abreast of Seal island, sounded from two to three fathom. We passed Seal and Gillam's islands, thinking to sail up a stream we met there; but it being neap tide, and we not knowing where the deepest water was, and seeing the tops of stones above water, at fifteen minutes past eight we returned to Seal island, where the water was fallen half a foot; and landed at forty-five minutes past eight; pitching our tent on the N.E. point of Gillam's island.

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[1] An account of six years residence in Hudson bay from 1733 to 1736, and 1744 to 1747, by Joseph Robson, London, 1752.

Tuesday, the 16th, in the morning, Captain Fowler and I went round Gillam's island; we climbed up to the west end, which is very steep, to look up the river; we imagined, that if we had got up that stream, and we were very near the head of it when we turned back, we might have sailed in the long boat a great way farther up the river; at thirty-nine past eight, we returned to our tent. After breakfast we left two men to take care of the boats and went down the north shore of the river, to observe the flats at low water. When we were five miles below Flamborough head, we climbed up to the top of the bank, where we saw the lower end of the middle ground, the top of some large stones being above water; flood at thirty minutes past five this afternoon. From the place where we stood to these stones on the lower end of the middle ground, and to the outer point of woods on the south shore, it bore E. half N. As we went down the shore we saw plainly there was a channel on the north side, and another on the south side of the middle ground; we thought the channel on the north side the best, and it lay close to the shore, within half a cable's length of it; all the way from two to three miles above the lower end of the high land up to Flamborough head, and from two or three miles above the foot of the high land, the channel is in the middle of the river, leading out of the river's mouth.

'This north shore lies 42 degrees N.E. and S.W. and is a sand from the height of three-quarters flood to low water mark; towards high water mark close under the bank, it is full of large pebble stones; there are several small creeks along this shore, where we found tenting poles left by the Indians who had been there to fish; it thundered and rained much while we were upon this journey. Between Seal island and Flamborough head there are large parcels of fine trees growing close to the river side. Fifteen minutes past eight we got to our tent, having suffered much from the muskettos.

'The captain and I judging these islands very proper to make settlements upon, the lesser island being as we apprehend an extraordinary fine place for a fort to secure that river, I made a particular survey of these islands, as follows:—

'Wednesday morning the 17th, surveyed Seal island, and found its length 21 chains or 1,386 feet. Its breadth 4 chains or 297 feet. Its circumference at high water mark 62 chains or 4,092 feet. Its perpendicular height 86 feet. Its form resembles a long oval. Its height from low water mark makes an angle of 33°. Length of the slope 2 chains 40 links. We sounded the water round the island, from 2 to 3 fathom on the N.W. and N.E. sides; the S.W. and S.E. sides lie to the main river, being shoal water near the island, but at half a mile from the island the water is deep; between this and the larger island above it, there is two fathom and a half and three fathom water, where a vessel may lie safe both in winter and summer, and a vessel of eight or nine feet water may get up safe to this place. At the N.E. end of Seal island, on the main shore, is a very fine low bottom, where grow a parcel of as fine trees as I had seen in the country, close to the river; we cut our names on the trees in the N.E. end of Seal island. The breadth of the water that parts Seal island from the larger island above it is 8 chains or 176 yards; this larger island is about three miles in circumference, the west end being as high as any land thereabouts; neap tides flow here, about four feet and spring tides about eight feet; but the chart of this river will best show the situation of these islands. Along the river side are the stones already mentioned, round as cannon balls, which when broke look like iron. At forty-five minutes past eight, almost high water, we made sail to go down the river wind S.W. sounded from the N.E. corner of Seal island, from three fathom and a half to five feet; from five feet to four fathom and three-quarter just above Flamborough head, then eleven feet, then three fathom, then two fathom just below the head; water fallen half a foot. From the head downward the shore lies N.E. by N. and S.W. by E. nearly; the channel lies within half a cable's length of the shore; the least soundings down this channel were ten feet. The water fallen a foot about one mile and a half above the foot of the high land in the north side of the river; we stood off from the shore near a mile and sounded two fathom then stood in and shoaled gradually to nine feet; we stood off and on several times, and found the bottom near level; sounded off shore a mile, found twelve feet water, then stood in shore, the water shoaled gradually to nine feet. At forty-five minutes past ten, we were a little below the foot of the high land, and stood across the river; found the channel in the middle from three fathom to three fathom and a half, half a mile broad; in the middle of the channel four fathom and a half, soft clay. By working down this channel, towards the river's mouth, we found it steep on each side, when we stood into two fathom and a half before we put the helm a lee; ere the boat was stayed she shot into ten feet water. When we came pretty far down, seemingly without the river's mouth, we stood into two fathom and a half on the south side, then stood to the northward till we sounded four fathom and a half, then to the southward till we sounded three fathom, then to the northward till we sounded eight fathoms and a half in the best of the channel. The channel is deeper here than farther out, for as we came up we crossed the channel three times without this place, and had only six fathom. From eight fathom and a half we stood to the S. eastward about three miles, saw a point or ridge of stones on the south side, distance three-quarters of a mile, sounded three fathoms; this point of stone dries four or five feet perpendicular, and seems to lie two or three miles from shore; but there are flats that dry at low water all the way to the shore, so that a man may walk from these stones to the land; then we stood northward; the water deepened little in half a mile. When we had stood a mile northward, we saw stones dry on the north side, distance three-quarter of a mile; sounded three fathom and a half to four fathom (now we were almost as far out as when we steered N.W. across the channel in going up the river, and had six fathom). Then we steered E.S.E. two or three miles. Keeping three fathom near the south flats, towards low water (it was low water when we were hereabouts in our progress up the river) made a little trip to the northward to deepen out water; wind at S.W. a fresh gale; hawled up for the ship, which we saw very plain in Five-fathom-hole all the way after we had passed the point of stones mentioned above, and got aboard at fifteen minutes past seven in the evening.'

In connexion with the proposed utilization of the mouth of Nelson as a principal harbour on Hudson bay, the average dates of opening and closing of Hayes river, at York Factory, for a series of years is of interest. Dr. Bell has published[1] such a record for the years 1828 to 1880. From it the following summary is made:—

1846—	Earliest opening..	May 7.
1851—	Latest closing..	Dec. 9.
	Average date of opening..	May 19.
	Average date of closing..	Nov. 20.

or an average of six months during which the harbour is open.

Since the foregoing paragraphs were written the Report of the Department of Naval Service for the year ending March 31, 1911, has been issued. The following excerpts relating to the navigation of the bay and straits are taken from the report of William J. Stewart, Hydrographer, published on pages 32-41:—

'He (Captain Bartlett) furnishes the following interesting report on the trip, particularly on the ice conditions met with:—

'Ice conditions. Great numbers of icebergs were met with along the Labrador coast. These bergs are reported by fishermen to be much more numerous from the coast to 20 or 30 miles off than farther out. Probably the best course for a vessel, making from Newfoundland to Cape Chidley, would be about 50 miles off the land.

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[1] Geol. Surv., Canada, Report of Progress, 1879-80. App. VII. Table showing dates of the opening and closing of Hayes river at York Factory, compiled from authentic records by William Wood, Meteorologist, York Factory.

'Cape Chidley was rounded and Gray strait entered at noon on July 18, the ship anchoring in Port Burwell at 3 p.m., the same day.

'Port Burwell and the bays along the coast were found to be quite clear of ice, but in Ungava bay, as far as could be seen from aloft, the ice appeared solid. From information obtained from the mission at Port Burwell, this field has been held in Ungava bay by a long period of light northerly winds. It also appears that this year the ice in Burwell and adjacent bays had broken exceptionally early (about July 10), but as a rule it may be taken that it is impossible to enter these harbours till the last few days of July. In 1909, on the day corresponding to that on which I entered Port Burwell, dog teams were still crossing the harbour on the ice.

'On leaving Port Burwell, July 19, heavy field ice was encountered at a distance of about 30 miles. This had apparently set out from Ungava bay and drove the ship a considerable distance north toward Resolution island. The extent of this field was about 60 miles, after which a sheet of comparatively clear water was passed through until 10 p.m. of July 20, when very heavy ice was met with. This kept the ship to the southward and made it necessary to abandon any idea of making Ashe inlet.

'In the opinion of Captain Bartlett this was Arctic ice, being much heavier and dirtier than that from Ungava bay.

'This pack appeared to be continuous from the northward to within a couple of miles of the southern shore of Hudson strait (Cape Prince of Wales to Digges island), a narrow passage along the shore being apparently kept fairly clear by tidal streams.

'After a short spell of clear water off Cape Digges, about 40 miles of heavy ice drove the vessel toward Nottingham island.

'Monsel island having been passed, the southern point of Coats island was steered for and course set for Churchill.

'Towards evening on July 22, the ship struck the outer edge of the largest ice field met with on the whole voyage. This, for a distance of about 200 miles, was continuous. This ice was not very heavy for a vessel specially constructed, but called for considerable skill on the part of Capt. Bartlett, the ice pilot, in finding leads.

'There being no indication of clear water on either side it was resolved to make as direct a course as possible. The ship was seldom stopped, but was heavily shaken by the continuous pounding necessary to force her way through.

'This field was suddenly cleared on the morning of July 24th, and Churchill was reached the same night without further delay.

'Churchill and Nelson having been visited, the vessel left the latter place on the evening of July 30, on the homeward voyage. Within a few hours of leaving Nelson the heaviest ice yet met was encountered, and for about 90 miles very slow headway was made. This having been cleared, nothing but light ice was met, either in the bay or strait, until after leaving Port Burwell. Whilst at anchor at Port Burwell awaiting the arrival of the *Earl Grey*, the ice set out of Ungava bay before a moderate southerly breeze, and Burwell harbour was completely filled. The ice was, of course, loose, but made boat work impossible at times.

'Port Burwell was left upon August 9, and within an hour the ship for the first time encountered ice that stopped her. This had evidently been heavily packed in slack water, the flood carrying its own ice to meet that returning through Gray straits on the ebb. When the strength of the tide made itself felt, the ice holding the ship was loosened and by keeping close along the southern shore of Gray strait, Cape Chidley was rounded and course set for southward. The pack was apparently very heavy up to the Button islands.

'Very few bergs were seen on the return along the Labrador coast.

'Whilst numerous bergs were met with in the eastern part of Hudson strait, none were seen in Hudson bay itself, and Captain Bartlett informed me they are practically unknown there.

'It would appear from the above remarks that vessels may expect to meet ice from Cape Chidley to Churchill, but Captain Bartlett's opinion was to the effect that our experience was exceptional, and that a long spell of light winds had contributed to the packing of the ice. Personally, I cannot see why this should be so, as the ice forms and breaks away year by year, some years (as the present, 1910) exceptionally early, no doubt, but it must be met some time during the navigation season. Long spells of wind in one direction might hold it in the bays and inlets for some time, but it is not likely that these winds would be so continuous as to keep it there until frozen in again. Therefore, any vessel navigating the bay must be prepared to meet ice. Whilst none of that met with on this voyage could have been dangerous to the *Stanley*, or sealers and other specially constructed vessels now trading in the district, I am of the opinion it might be dangerous to a ship not so built. I certainly do not think any cargo vessel of ordinary construction would have been able to find or force her way through the large field met before Churchill, but would have been obliged to remain in the ice until it was loosened by winds or currents.

'Under the weather conditions which prevailed whilst the *Stanley* was in the bay, a ship might wait an indefinite period for the ice to open up again. In the event of a strong breeze which would eventually disperse it, the preliminary would be a heavy packing to leeward, which might jeopardise the vessel.

'Throughout the above remarks "ice" is to be taken to mean ice fields and not bergs.

WEATHER CONDITIONS.

'The *Stanley* was exceptionally fortunate in weather while in Hudson bay and strait, nothing more than a moderate breeze being experienced. But, as a general rule, in the strait and bay proper, no lasting heavy weather need be anticipated during July and August, although in the vicinity of Nelson river, heavy "northers" in August are reported by the Hudson Bay vessels, sometimes lasting from 36 to 48 hours.

'A considerable amount of fog was met with, which would be expected with the light winds prevailing during the voyage. This fog was usually in the vicinity of ice, but not necessarily so.

'Temperatures in the bay and strait were not low, the air averaging between 31° and 40°F., sea water between 30° and 40°F .

'Owing to the uniform temperature of the water, little can be judged from this as to the vicinity of ice. This was also noticed after clearing the straits of Belle Isle, that is to say, that the colder currents having been entered, the proximity of even large bergs made little difference to the temperature of the water.

GENERAL NAVIGATION.

'Apart from the ice question which it will be seen is by no means insurmountable, the dangers and difficulties of the navigation of Hudson strait and bay arise chiefly from the inaccuracies of the charted positions of the salient points, and from the proximity of the magnetic pole, with the consequent effect on compasses.

'As the whole of the Hudson Bay chart appears to be more or less in the nature of a sketch or running survey, great caution would naturally be exercised by the ship masters in making land.

'From my experience on this voyage, the land and islands are in some cases 15 to 20 miles out of longitude. This may be modified when I have reworked the many observations taken, but in any case it would be unwise to attempt to make any land except in daylight and clear weather.

'The Button islands, southern shore of Gray strait, and the land between Cape Prince of Wales and Digges island, as shown on chart, bear little resemblance to the actual coast. King and Joy islands do not exist, and Charles island lies much closer to the mainland than the chart shows.

'I would have endeavoured to run a line of soundings on the outward voyage, but having a schooner in tow, and being so beset by ice, this was impossible. When able to do so on the return from Port Nelson to Cape Digges, I ran an almost continuous line, soundings being taken at intervals of 10 miles in deep water, and 5 miles in shoaler water.

COMPASSES.

'As regards the great "bugbear" of Hudson Bay navigation, the reported local attraction and inaccuracy of the compass, I found nothing to justify this evil reputation. In one or two places only, and when in close proximity to the high land (Cape Chidley and Cape Digges, for instance) I found a deviation of two or three degrees from the normal. Whilst in southern waters, Halifax and Strait of Belle Isle, I had very carefully adjusted the compass of the *Stanley*, which was excellently placed as far as the ship's magnetism was concerned, and had reduced the error due to ship to such small amounts that almost the whole of the compass "error" as found by observation in the bay could be accepted as due to variation, as opposed to deviation.

'Being exceptionally fortunate in having clear sun and stars, my observations for error were almost hourly, and showed that the change of variation, though rapid, was normal, but the lines of variation will not quite agree with those shown on admiralty charts. For instance, the line of "no variation" lies about 30 miles east of that shown on chart. As stated above the proximity of the magnetic pole (and consequent small value of horizontal force) renders the needle sluggish and an alteration of a few degrees in direction of the ship's course is not immediately shown by the compass.

'As the chart stands at present, continuous observations for compass errors are necessary. This is only in accordance with the ordinary practice of seamen, and I think that when the lines of equal variation have been correctly charted (and positions rectified) no more difficulty will be found in the navigation by account than is experienced in the approaches to the Gulf of St. Lawrence, where the rapid change of variation necessitates hourly alterations of the course.

'It may be remarked that a liquid compass was found to be almost useless, especially in the western portions of the bay.

TIDES AND CURRENTS.

'As far as could be observed from the high water marks along the coasts passed, the H.W.F. & C., was much as shown on chart. The many deviations from the course, made necessary to avoid ice, prevented any reliable data being obtained as to the set of the currents, except that, as would be expected, a strong tidal set was felt in and out of the bays and indentations of the coast. In Gray strait the spring tides are so strong that it is advisable to time the aproach to pick up a favouring stream.

Ports Nelson and Churchill.

'Until the results of the detailed surveys are in, it is difficult to give an unprejudiced opinion as to the relative values of Fort Churchill and Port Nelson as ports, and I can only take the point of view of a master of a vessel making these places for the first time without local knowledge or pilot's assistance.

'When making Port Churchill, having obtained good sights for latitude and longitude at 5 p.m., and later picking up soundings, I proceeded until 11 p.m., when the distance being run down, I hauled to the southward for the port. Fog came down and I anchored for the night. When the weather cleared about 10 a.m. the following day, the beacon at the entrance to Churchill harbour was seen, the harbour easily entered and a comfortable anchorage picked up.

'I give this detail to show the facility with which the port can be made.

'Churchill harbour, although of not very great extent as it at present stands, appears to me to be adapted to easy enlargement, the eastern shore having good water close to. The entrance is narrow and I do not imagine any sea could get up that would inconvenience loading operations alongside wharfs, but the heavy tide and current from the Churchill river running against a strong breeze makes boat work difficult at times.

'The land in the vicinity of Cape Churchill is rocky with stunted trees, the highest part of this land being about 100 feet above H.W.

'The dangers shown on Admiralty chart No. 863 as being off Cape Churchill are locally stated to be much nearer the land.

'Having left Churchill on July 27, I proceeded to Nelson Roads.

'The land in the vicinity of Cape Tatnam and the western shore is very low, the summit of the trees being certainly not more than 50 feet above H.W. The ground on the approach to Port Nelson or York Roads was found to be very foul.

'Four fathoms of water was picked up with no land in sight, and eventually anchored in nine fathoms in a position where the trees were only visible from aloft, and a beacon which is situated near the entrance to Hayes river and the summit of which is 80 feet above H.W., was just visible from the ship at a height of 40 feet above the water. Although only 80 feet high this beacon can be seen some time before any other sign of land is visible.

'The day following my arrival, I ran with a launch to Hayes river and found that a drying flat of sand and boulders extends about three miles from the shore, less than 18 feet of water for a further four miles, and less than 30 feet for an additional three or four miles.

'The current from the Nelson and Hayes rivers is very swift, a great volume of water being discharged into Nelson Roads. When this current combines with an ebb tide and sets against the heavy northerly gales which prevail here in August and September, a very bad sea is raised, especially, as may be imagined, inside the five fathom line of sounding. The Hudson Bay vessels have found difficulty in making, and holding, their positions in Nelson Roads and on more than one occasion have been obliged, after waiting some days for favourable conditions, to abandon all idea of discharging. They have then carried their cargoes on to Churchill, from whence it had to be drawn by dog teams during the winter. The usual procedure for the Hudson Bay vessels is to close the land as much as possible on the rising tide, and on their signals being observed by officials ashore, to steam out and anchor at a distance of about 18 miles and await the boats.

'In August, 1909, one of these vessels experienced a northerly gale of 48 hours duration, during part of which she was steaming full speed with both anchors down, with a heavy sea breaking on board. After remaining in the vicinity for ten days, and being unable to work, she proceeded to Churchill and there discharged her Nelson cargo.

'After leaving Port Nelson anchorage I sounded my way out to the northeast and carried good water for some miles until, at an estimated distance of from 12 to 15 miles from Cape Tatnam, I suddenly picked up 10 fathoms and thought it advisable to haul due north. The ground in the vicinity of Cape Tatnam is reported locally to be as foul as that on the western side of Port Nelson.'

"As a result of Mr. Bechand's survey at Port Churchill, I beg to offer the following report":—

'Churchill harbour is situated in latitude 48-56-10 N. and longitude 94-10 W. and about the middle of the west shore of Hudson bay.

'The approach to Churchill harbour is very well marked and comparatively easily picked up. The first landfall (aproaching from Hudson strait) is Cape Churchill, which stands well out from the low west shore and in contrast to the shore south of it, may be approached to within a comparatively short distance. From this cape to the harbour is a distance of 35 miles and a vessel may keep close enough to have the shore in full view until Eskimo Point and beacon at the entrance are made out.

'This clear approach is important and in marked contrast to the approach to the whole shore from near Cape Churchill to James bay, which is fronted by a shallow band many miles wide.

'The entrance to Churchill between the 18 foot contours is 1,100 feet wide and has as much as 90 feet of water in it with not less than six fathoms outside.

'The harbour itself is in two parts, outer and inner, but the latter is so shallow as to be useless and injurious to the former, in that it furnishes a large area in which water is stored during flood tide to cause strong currents through the entrance at ebb tide.

'The outer harbour or harbour proper is about 3,000 yards long north and south with an average width of 2,000 yards giving an area of one and a half square miles most of which, however, is very shallow. The area of water over 18 feet deep inside the entrance is about 1,600,000 square yards or about half of a square mile. The anchorage space is, therefore, not suitable for more than three or four vessels.

'The east shore of the harbour is a long narrow point not over 40 feet high tapering from 3,000 feet at the inner end to a small rock at the entrance. For a distance of 6,000 feet from the entrance this point is fronted by a shallow band and a lane of water 700 feet wide over 18 feet deep. If this harbour should be selected this would give an excellent site for sufficient slips and piers for a large traffic.

'The west shore of the harbour is another point about 8,000 feet wide and terminating in a small island and the remains of old Fort Prince of Wales. This point is not considered so suitable for wharfs, piers, and ships or railway yards.

'Not being provided with the necessary apparatus, no borings of the bottom were taken, but as far as observed it is silt from the river.

TIDES.

'The range of the spring tides is about 15 feet and the water rushes through this entrance with a velocity of 6 miles per hour on the ebb tide and 2½ miles per hour on the flood. As remarked in the beginning of this report the inner harbour is very large and allows a large volume of water to be impounded furnishing a supply that must escape during the ebb and cause heavy currents. The harbours might be separated by a dyke and thus provide a wet basin above and cut off the supply for the strong currents at ebb tide.

SHELTER.

'The entrance being narrow, no sea of any consequence can come in, but when northerly to northeasterly gales blow, some sea strikes the west shore for a short distance inside the entrance and creates an uncomfortable condition for vessels anchoring off the R.N.W.M.P. post, particularly with the ebb tide. A vessel anchoring closer under the eastern shore experiences little inconvenience from sea or tide, and in the situation suggested for the wharfs and piers a vessel would suffer none. The high winds will, of course, be felt as the shores are comparatively low and void of trees.

ICE.

'In 1910, floating ice first appeared from the river on October 15, and the harbour was closed on December 5. The survey party reached Churchill on July 25, and no ice was seen afterwards; first snow appeared on September 9, but the season was reported to be an unusually short one.'

"As a result of Mr. Parizeau's survey at Nelson river, I beg to offer the following report":—

'Port Nelson is situated approximately in latitude 57-03 north and longitude 92-35 west, or about 120 miles south of Port Churchill. . . . .

'On the trip heavy ice was encountered and the vessels were unable to call at Ashe inlet for magnetic observations as intended. A track was, however, discovered along the south side of Hudson strait close to land and the bay entered on the 22nd. Across the bay heavy ice was found until within 70 miles of Port Churchill, after which no trouble was experienced.

'At the present time anchorage is taken up at a great distance from shore. The Hudson's Bay Company ships run in as close as possible on the high water to signal the post at York Factory and when seen they leave and anchor about 18 miles from Point Marsh.

'Last season when approaching Nelson river to put the schooner on the station for her work, the steamer *Stanley*, with her in tow, ran into shallow water (4 fathoms) then moved out to 9 fathoms and fixed her position as 10 miles from land where nothing could be seen from the deck and only a few trees and the beacon on Marsh Point from the Crow's Nest.

'After becoming acquainted with the locality and procuring a pilot the schooner was piloted at high water to an anchorage just off the position selected for the outer railway wharf.

'Owing to the great difficulties encountered very little surveying that can be placed on paper was done. The greatest labour was necessary to get ashore with material for signals and owing to the low beach these had to be large and high that they might be seen a few miles off. The winds and seas were very heavy and in the exposed situation working from even a large well covered-in launch was impossible.

'If very little of a definite nature was ascertained, a good deal of information that will be of material assistance next season was obtained.

'At a point 15 miles from the beacon on Marsh point and the same distance from Sam's creek, there is a depth of only ten fathoms. The water towards the river gradually shoals and the river channel develops until at a point midway between Marsh point and Sam's creek, a bar is reached over which not more than 21 feet can be carried. Here the channel at low water is about 600 yards wide, the banks on either side drying at low water. Inside, the channel deepens again and continues for seven miles to the position selected for the outer wharf, where only 17 feet water can be found and the channel is about 600 yards wide.

'Observations for tides show that springs rise 16 feet and neap 10 feet, and the tides flow and ebb at from 2 to 3 knots.

'Of course, this information is all gathered from cruising about in bad weather, when circumstances made it impossible to fix one's position for transfer to paper and when the survey work is completed it may have a different appearance.

'There is one thing certain that the survey is no child's play, the roadstead is exposed to every wind that blows and every sea that runs, the currents and cross currents are strong, the shores are so low that nothing can be seen from boats and all locations must be determined from the previously ascertained position of the ship.

Ice began to form, coming down the river on one tide and up on the next, on October 31, and gradually became worse, each day making navigation more hazardous.

'Until further and proper definite information is obtained, no opinion can be expressed as to the suitability of this port for a terminus.

'On September 12, it was decided to send the schooner to Halifax and continue the work from camp until the ice would render moving about dangerous.

'The schooner, therefore, sailed, arrived at the western entrance to Hudson strait on the 15th, and at the eastern entrance on the 21st, having experienced strong gales and snow storms and thick weather, almost all the way. Twelve icebergs were seen off Ungava bay. The vessel reached Brigus, Newfoundland, on October 7.'

Saskatchewan River.

The Saskatchewan takes its rise in many streams flowing from the eastern slopes of the mountains. These form the north and south branches, which unite 26 miles below Prince Albert, to form the main river which has there attained nearly the full volume which it carries to Lake Winnipeg. The North Saskatchewan, on which are situated Prince Albert and Edmonton and many smaller towns, has a length to its junction with the South Saskatchewan of 760 miles; and the South Saskatchewan, with Saskatoon, Medicine Hat, Lethbridge, and Calgary along its course, is 865 miles long; the main Saskatchewan from the forks to Lake Winnipeg is 340 miles long.

The river, from far above the forks, flows between high scarped banks of clay, 80 feet or more in height, with here and there short stretches, the sites, probably, of old landslides, where the high land lies 15 or 20 chains back and the immediate banks are not more than 10 feet above the water. The section exposed by the scarped banks shows occasional boulders scattered through the sandy clay and, for many miles, a very persistent, horizontal band, formed of flattened pebbles or boulders lying at intervals of a few feet from one another, stands out prominently along its face at a height, near the forks, of about 40 feet above the water; 30 feet or more of light yellow sandy clay overlies the boulder band. The even distribution of these boulders gives the impression that they were dropped by floating ice. Hind noticed very similar conditions on the South Saskatchewan, below the Elbow.[1] 'Two tiers of boulders, separated by an interval of 20 feet, are visible in the clay cliffs lower down the river. Where first noticed they were about 15 feet above the water. As we descended the river, they were seen to rise above its level, preserving evidently a nearly horizontal position. The lower tier consists of very large fragments of water-worn limestone, granite, and gneissoid boulders; above this is an indurated sand, containing pebbles; this is superimposed by an extremely fine stratified clay, breaking up into excessively thin layers, which envelop detached particles of sand, small pebbles, and aggregations of particles of sand. Above the fine, stratified clay, yellow clay and stratified sand occur. The fine clay must have been deposited in very quiet water; a microscopic examination, subsequently made, failed to reveal any diatomaceae.'

Below the forks, the river becomes very strikingly beautiful, with long stretches where the higher land slopes down to the river flats in gentle, grassy hillsides, clothed with an open growth of small aspen and Banksian pine. An alternation of low, rounded, stable banks and high, steep, and unstable walls characterizes the stretch of river down to below Nipawin rapid. The width is a little less than one-fourth of a mile and the current swift. Below the rapid the banks have more gradual slopes and the current is not so strong; the channel widens and becomes shallower, and many sandbars and islands appear. For a short distance, where the river contracts at Tobin and Squaw rapids, the banks are again steep and high, but below the rapids fall away to a height of 10 feet or less and continue low to the mouth. This long stretch of river-valley extending to Grand rapids near the mouth, has the character of an estuary, in which the low, flat land is broken only by a few ridges of boulder clay; of these the most prominent are those through which the river breaks at the Barrière below Tearing river and at the Pas. The elevation of the land above the general river level is not more than 10 feet, and in many places is much less, so that in periods of flood the river overflows its banks and spreads over nearly all this low-lying land.

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[1] Canadian Red river and Assiniboine and Saskatchewan Expedition. H. Y. Hind. London, 1860.

The low, flat country forms a broad belt along this part of the river, extending northerly from the river for 15 miles, and southerly for 25 miles to the base of the Pasquia hills. Through it the river flows easterly, with a moderate current, and along certain stretches a rapid one. Many islands divide the current into various channels.

About forty years ago, at a point 33 miles above Cumberland House, the river broke through the 2 mile wide barrier of low land separating it on the north from the channel of Candle river, a large stream draining Candle lake, and flowing, in a course roughly parallel with the Saskatchewan, into Cumberland lake (Plate XVI). The break occurred during the period of the spring flood, the water following the course of an old canoe portage leading from one of the sharp northerly bends of the Saskatchewan to a southerly elbow of Candle river.

At first a small stream, the overflow has yearly increased in volume by wearing away its banks, until now, at low water, the old Saskatchewan channel carries but little water, and vessels of all kinds, even flat bottomed scows, follow the new channel. The great increase in the volume of water now flowing in what was Candle river has caused the stream to break through its banks in many places, and to carve out new channels through the low land, so that now the water follows many meandering courses, which reach Cumberland lake through mouths situated at various points along 12 miles of its southern shore. Even after reaching the lake the water keeps to a river-like channel, skirting the northern shore and separated from the lake by long, narrow, wooded islands that form an almost continuous barrier, the gaps between them being few and narrow. The water rejoins the old channel of the Saskatchewan by the Bigstone and Tearing rivers, the two old outlets of Cumberland

PLATE XVI.

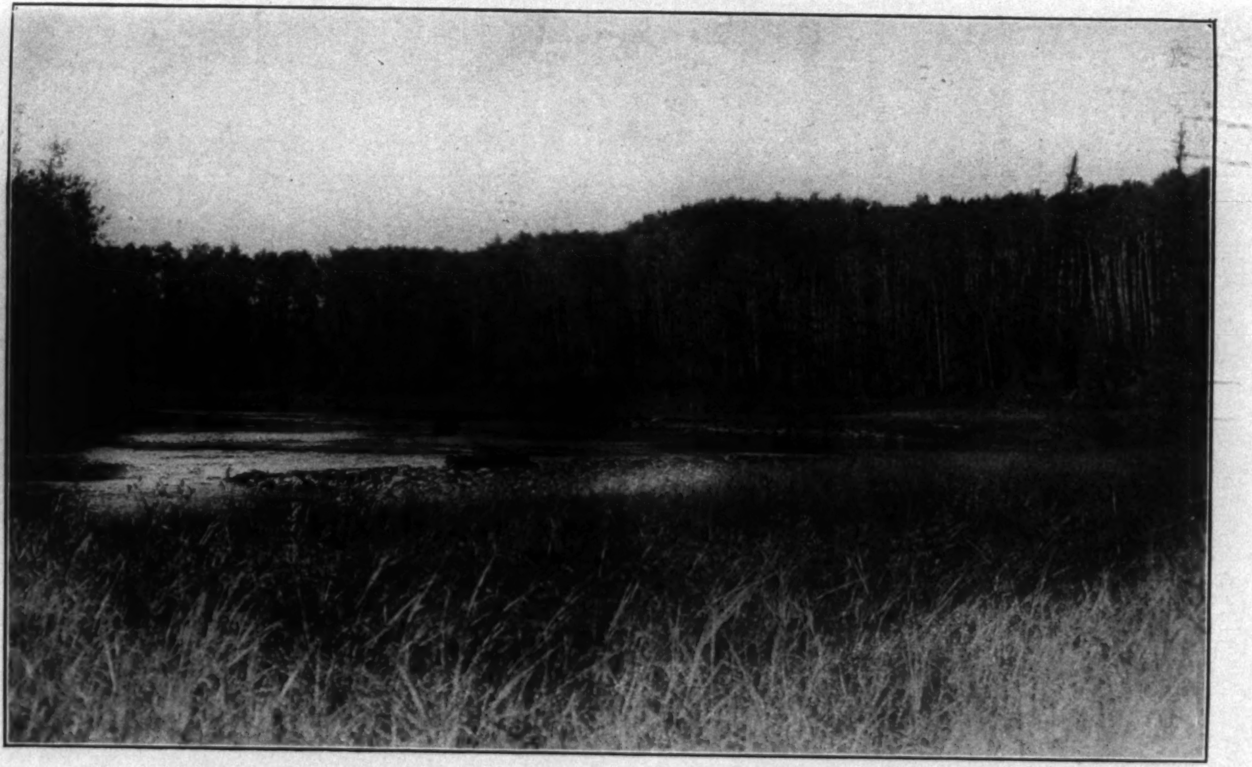

Photo by W. McInnes, 1910.

Candle river : a view typical of the Saskatchewan valley as the higher land is approached.

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lake, now, however, augmented by the increased volume of water into rivers with broader and deeper channels than formerly. The water of the Saskatchewan always carries a large amount of suspended, silty matter, and, from the greater abrasion along the new channels, pours into Cumberland lake a still more murky flood. The sedimentation due to this, together with the wearing down of the outlet channels by the increased flow of water through them, has already made the lake so shallow as to be navigable, in low water, only through tortuous channels leading to the two outlets (Plate XVII.)

Another channel, known as the Sipanok, by which part of the water of the Saskatchewan flows across to Carrot river, breaks through the right bank about 9 miles below Squaw rapid. Except at extreme low water in the Saskatchewan a good volume of water flows through this winding channel, which has a length of 60 miles. At the Saskatchewan end the banks are about 15 feet high but gradually become lower, until at the Carrot river they are only a few feet above low water level and are flooded at high water.

Between the Pas and Cedar lake many winding channels leave the main stream and form, in places, a network of streams meandering through the low, swampy land. The first outcrop of the underlying, solid rock occurs at a point 37 miles below the Pas, where shelving ledges of magnesian limestone appear in the bank of the river. At Kettle point, 21 miles lower down, are exposures of similar limestone. Outcrops of magnesian limestone in low, horizontally bedded ledges, occur at intervals through Cedar lake and down to the mouth of the river. At the upper end of Cedar lake the estuarine character of the valley is most marked; the river is divided into many channels, with interlacing, connecting branches which meander through low, swampy land, forming a maze of islands covered with reeds and rushes.

Except to the south, where the ridge separating the lake from Lake Winnipegosis rises to a height of nearly 100 feet, the land adjoining Cedar lake is very low and swampy and wooded only with small willows, which form fringes along the river banks. Between Cedar lake and Cross lake one rapid occurs with a descent of about 6 feet; and between Cross lake and Grand rapids are two small rapids, both descending over flat ledges of limestone. At Grand rapids, the principal fall on the river, the descent is in the vicinity of 100 feet in a distance of less than 4 miles. This portion of the river has been described in some detail by various travellers, particularly by Fleming,[1] Klotz,[2] and Tyrrell.[3] By Tyrrell the geological section is thus described:—

"Ascending the Saskatchewan river from the point where it empties into the west side of Lake Winnipeg, the banks for a short distance are low, but they almost immediately rise to a height of 15 feet and maintain this height up to the foot of the rapids at a distance of 2½ miles from the lake. They are generally sloping and covered with grass, but they appear to be composed entirely of a light yellowish-grey till, while the little beach at the foot of the abruptly sloping bank is strewn with many irregular fragments of white limestone.

Just above the Hudson's Bay Company's post, on the west bank of the river, an old abandoned channel joins the main course of the stream. It varies considerably in width, from a quarter of a mile at its mouth to about 200 yards a mile farther to the south, where it again joins the main channel of the river. At this latter point its bed was 5 feet above the level of the surface of the river in August, 1890. A short distance from the upper end of the channel a small stream begins to flow down the channel, and after babbling through and among the irregular, angular stones with which its floor is covered, falls into the bay at its mouth. In seasons of flood some of the water of the river is said still to flow down this channel. Its banks are from 40 to 50 feet high, but are throughout covered with trees or deciduous plants.

On the east side of the old island, which is cut off by this abandoned channel from the high land to the west of it, the river is in some places still cutting down its bank. At one place a few hundred yards below the head of the old channel, a low exposure of Niagara limestone is seen close to the edge of the river, rising at its highest point to 2 feet above the water. Its bedding is essentially horizontal and its surface is smooth and glaciated with strongly marked parallel grooves bearing S. 2° W.

The rock consists of a brecciated magnesian limestone, the pebbles in which are milk white, very compact, though rather soft, and highly argillaceous, breaking with a vitreous fracture. The matrix, which is much harder but less compact, and often slightly porous, is yellowish-grey, and breaks with a stony fracture. The rock is rather thinly but irregularly bedded, and along the edge of the water, weathers to a light yellow, while the upper part, away from the water, weathers to bluish-grey. No fossils were found in this band.

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[1] Report on the Exploration of the Country between Lake Superior and the Red River Settlement and between the latter place and the Assiniboine and Saskatchewan. by S. J. Dawson, Esq., C.E., Toronto, 1859.

[2] Dept. of the Interior, Canada, Annual Report, 1884-85, Part II.

[3] Geol. Surv., Canada, Annual Report, Vol. V, 1890-1, Pt. E.

PLATE XVII.

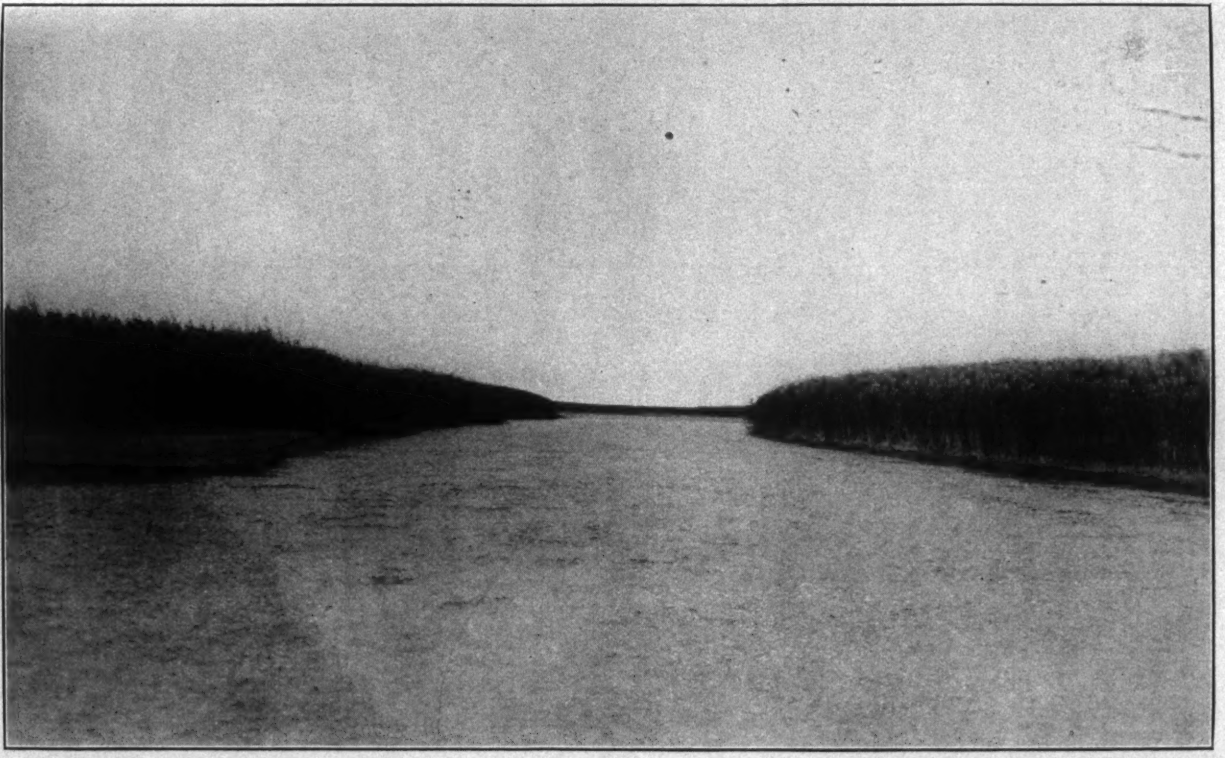

Photo by W. McInnes, 1910.

"Cut off": west end of Cumberland lake, an estuary in process of being silted up by the Saskatchewan river.

A little farther south, on the same side of the island, a scarped and springy bank 35 feet high shows the section of the Pleistocene deposits represented on the following page. The face of the upper portion of the cliff weathers to a milk white. The line between the upper till and the stratified clay is not very sharp, the one appearing to merge almost imperceptibly into the other, while the pebbles become larger and fewer in descending to where the clay is more distinctly stratified. The sand below the clay is very fine at the top and passes downwards into a fine gravel. The lowest bed of till is partially covered with debris, but both the top and bottom were clearly seen. A considerable flow of water rises from the band of sandstone, and the bank below it is generally covered with debris consisting of angular fragments of limestone, much of which is derived from close at hand.

The rest of the west bank of the old island, with the exception of the low outcrop of Niagara limestone mentioned above, is covered with debris from these surface deposits, and boulders and pebbles are scattered along the edge of the water. One very large boulder of limestone, 15 feet in length, is lying in place on the glaciated surface of the limestone, still partly embedded in the bottom of the till. It is strongly glaciated, the sides being everywhere scored with striæ.

Following the north bank of the river, above the upper end of the old channel, to the first prominent point, a thick-bedded, buff coloured dolomite crops out at the edge of the water, holding a large number of *Pentamerus decussatus*, and then crossing to the south side of the river, in a direction 25° south of east, the Pentamerus band is again seen, with a thickness of 2 feet. It is exposed at the top of a little cliff, and is underlaid by 9 feet of whitish, moderately thinly-bedded, unfossiliferous dolomite. One foot at the bottom is more yellowish and a little thicker bedded than the rest. The brecciated zone is not seen, but is doubtless only little below the beds seen in this cliff.

In the Pentamerus band at the top of the exposure *Pentamerus decussatus* is very abundant, and the following other fossils are found associated with it, viz.:—

Favosites niagarensis.
Alveolites niagarensis.
Lyellia papillata?
Halysites catenulatus.
Orthis, sp.
Euomphalus, sp.

Following up the south bank of the river for a quarter of a mile, the Pentamerus band, which has a total thickness of from 3 to 4 feet, disappears beneath the level of the water, and the cliff dies away and leaves a willow flat that may be the lower end of an old channel on the south side of the river. In one place, however, east of this flat, the Pentamerus band is overlaid by 3 feet of white, moderately thinly-bedded limestone. Continuing to ascend the course of the stream, soft yellow or white argillaceous limestones are occasionally exposed on both banks up to within a short distance of the foot of the old portage. It is difficult to give an exact section of the beds as, where they are unprotected by overlying, harder rocks, they have been more or less completely unmoved during Pleistocene times; and, where so protected, the foot of the cliff is buried in a talus of angular fragments from the dolomite above. They would appear to be from 40 to 50 feet thick, and the following is the ascending section, as seen, the width of the first gap being uncertain:—

Three feet of white, moderately thin-bedded limestone (mentioned above).

Ten (?) feet, covered.

Eight feet of a soft, light yellow, argillaceous limestone, generally porous and containing a large number of impressions of salt crystals. In places the bedding is moderately even and horizontal, but generally it is hardly discernible, and the rock breaks into very irregular, lumpy pieces. Lying on the shore and derived from this band, are some nodules of marcasite and red masses of ironstone.

Fossils are not plentiful on the south side of the river where this band is best exposed, but a low exposure in the north bank, that seems to be a continuation of that on the south bank, contains *Strophomena acanthoptera, Leptocœlia,* and *Leperditia.*

Six feet covered.

Fifteen feet of a thin-bedded, white horizontal, chalky limestone, in places argillaceous, very light and breaking regularly when struck with the hammer. It has a more or less granular structure, occasionally approaching a sandstone in appearance. One bed, near the top, was strongly ripple-marked, and on the edges of slabs broken from this bed, the action of the water that caused these ripple marks is seen to have extended down from an eighth to a quarter of an inch, and to be defined by a moderately even, horizontal line. A thin band, a few feet below the top, was found to contain a considerable number of fossils, among which the following have been recognized: *Favosites niagarensis*; *Leptocoelia,* sp.; *Rhynchonella,* sp.; *Plerinea aviculoidea?*; *Pleurotomaria occidens?*; *Pleurotomaria,* sp.; *Orthoceras,* sp.; *Gomphoceras parvulum*; *Leperditia coeca,* and *L. Hisingeri,* vars. *egena* and *fabulina.*

The white, lower Niagara limestone is sharply overlaid by a hard, tough, light yellowish, dolomite limestone, rather indistinctly bedded. It is generally clearly fragmental and, toward the base, contains a large number of impressions of salt crystals. Fossils appear to be moderately plentiful, but they are very difficult to break out and consequently few were collected. Crinoid stems are fairly abundant, and with them were *Favosites Gothlandica, Zaphrentis*, sp., and *Strophomena acanthoptera.*

This crinoidal limestone has a total thickness of 10 feet, and grades up into and is overlaid by from 20 to 30 feet of a hard, brittle, yellow dolomite, everywhere evenly bedded and often breaking into thin slabs. The only distinct fossil is a large Stromatoporoid, which occurs most abundantly in the upper strata, and often gives the surface the appearance of many closely adjoining, low domes. The rock is much jointed and breaks with a smooth porcellanous fracture.

These dolomitic limestones form the sides of the gorge, through which the Saskatchewan flows at the Grand rapids, standing in abrupt cliffs that often overhang the torrent below. On the south side the foot of the cliff is, in places, piled with a talus of angular fragments, while to the north side it descends abruptly into the water.

At the upper end of the rapids, these compact, dolomitic limestones are overlaid by a porous, yellow dolomite, generally in moderately thin but uneven beds, and containing many impressions of salt crystals. No fossils were obtained here, but on the tramway similar rock is exposed at a number of places, near the top of the grade, and at heights rising to 40 feet above the level of the top of the compact dolomite at the head of the rapids. It here contains *Lyellia papillata* (?), and several other species of corals, with some large Stromatoporoids. It is here best exposed in a cut through two gravel ridges, on the brow of a long slope, facing towards the east.

About half-way across the tramway a slight surface outcrop exposes 2 feet of horizontal, grey, white weathering, thick-bedded, tough but rather porous, dolomitic limestone, and immediately adjoining is a coarse breccia in which the pebbles are derived from the adjoining rock, while the matrix is dolomite, containing a large quantity of coarse, well rounded quartz sand. It would appear probable, from its very local occurrence, that this is a fault breccia, in which case the origin of the sand is an interesting question, as the only sands of the same character known in the region are the St. Peter's sandstone, at the base of the Cretaceous, though the nearest point at which the latter terrane has been actually observed lies 75 miles to the southwest.

. . . . A somewhat similar breccia occurs at Point Wilkins, on the west side of Dawson bay, the sand in which has undoubtedly been derived from the base of the Cretaceous. As the sand is much more likely to have run down from above, rather than to have been squeezed up from below, the presence here may denote the former existence of the Dakota sandstone previous to the wearing back, by erosion, of the great Manitoba escarpment."

Carrot River.

Carrot river, which joins the Saskatchewan 2 miles above the Pas, is a smooth flowing stream of moderate current for 150 miles above its mouth. For this distance the river is flowing through the very low land that characterizes the lower part of the Saskatchewan valley, though, near the upper end of the stretch referred to, the banks become higher, and at Red Earth Indian reserve are 7 feet above the common level of the river. A number of large, shallow lakes adjoin the stream, separated from it by a strip of higher, wooded land a few chains wide, which constitutes the bank. This narrow belt is becoming higher year by year by the addition to it of thin layers of silt deposited by overflow of the river, mixed with driftwood and rubbish carried by the flood and dropped in the slack current among the trees. From the crossing of the second base line westerly, the steeply sloping front of the Pasquia hills rises from the flat land to the south of the river all along. The hills rise first with gradual slopes, and higher up quite steeply to a height of about 1,600 feet above the valley or 2,500 feet above the sea. The hills are made up for the most part of Cretaceous sediments, though the base is probably formed of Palæozoic beds and the summit is covered by a varying thickness of boulder clay.

The only exposures of rock in place, met with on the mountain, were found in gulches eroded by streams flowing down the hill-slopes. They consist for the most part of soft, grey, fissile shales that contain a considerable amount of bituminous matter, enough to cause them to burn freely, with the emission of a strong odour of petroleum, when heated in the camp fire. The best exposures were found in the valley of the Nabi river, where 140 feet or more of thick-bedded, soft, grey bituminous shale or thin-bedded sandstone, holding the remains of fishes, bivalves, and foraminifera, are exposed in cliffs along the river; the species are characteristic of the Niobrara division of the Cretaceous.

Fifteen feet of clay-ironstone beds in layers 6 inches to 1 foot in thickness, with shaly parting, overlies the shale and is succeeded by 10 feet of soft, fissile, grey shale, similar to the thick beds below.

A varying thickness of boulder clay, the boulders chiefly of limestone but occasionally of Archæan gneiss, covers the whole.

Near the eastern end of the hills the bituminous shales were also found in the brook valleys. Their occurrence here and in the

PLATE XVIII.

22106—p. 108.

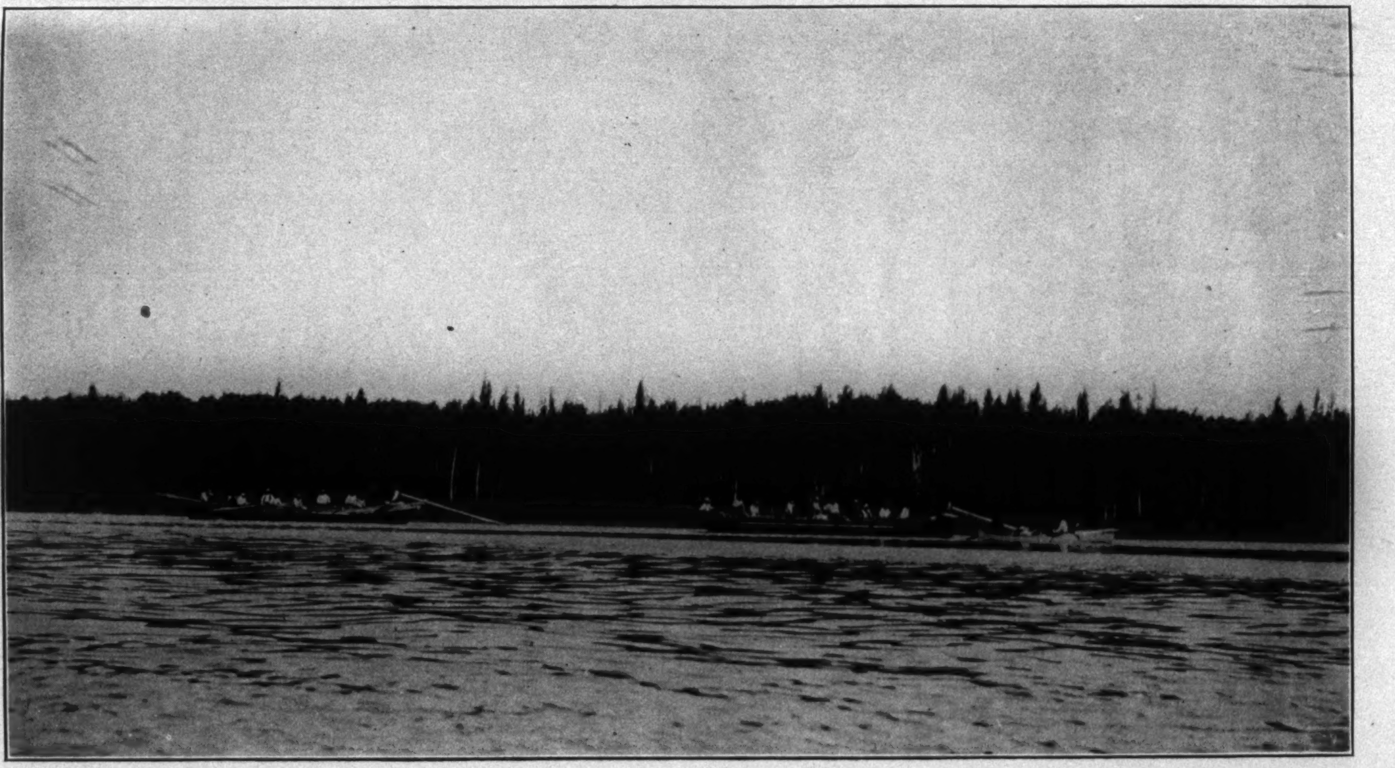

Photo by R. W. Brock, 1910.

York boats, returning from Oxford House.

valley of the Carrot river shows that they underlie the whole extent of the hill country.

The first rapids occur 4 miles above the Indian reserve, where the stream has cut its way through a ridge of boulder clay to bed-rock, and from this point to Kinistino, where it is crossed by the Canadian Northern railway, the stream is a succession of shallow rapids connecting stretches of deeper, rapid water. The ledges exposed at the first rapid consist of very rotten quartzose sandstone deeply stained with iron oxide and holding nodules made up mostly of iron pyrites. The sandstones occur in thick beds lying horizontally, and above them large angular blocks of hard, purple, quartzose sandstone, strongly ripple marked on the surfaces of some of the beds, protrude from the boulder clay bank. Thin layers of fine conglomerate, holding pebbles of gneiss and other rocks, occur in the sandstone, and false-bedding is plainly shown in it in places. Forty feet of tough boulder clay with striated boulders of sandstone, limestone, and gneiss, overlies the solid rocks. The sandstones seem to belong to the Dakota division of the Cretaceous. The ridge of boulder clay underlaid by sandstones, that forms this long series of rapids on the Carrot river, extends westerly towards the Saskatchewan, and is said by the Indians to be continuous to that river and to cross it in the vicinity of Birch island between the Nipawin and Squaw rapids.

The rapids, following the meandering course of the river, have a total length of 11 miles, and flow through high banks of boulder-clay for the lower 5 miles.

The boulder-clay gives place, half-way up the rapids, to rearranged glacial material, and, 3 miles from the head, to recent alluvial deposits that rise only 5 to 10 feet above the ordinary level of the river and are flooded at periods of high water, when the sediment-charged waters on their recession cover everything with a film of fine silt. High banks of lacustrine, stratified clay, rising from 20 to 50 feet above the river level, follow; a few miles farther on or from township 51, range 8, west of the second meridian westerly, land of very excellent quality is found on both banks. It extends back from the river in the form of a slightly rolling plateau 50 to 70 feet above the river with a rather sparse growth of small poplars. The subsoil is the stratified clay spoken of above, a lacustrine deposit that is overlain by a deep, black, loamy soil. In parts, this country might be classed with the mixed prairie and wooded lands, and everywhere the open growth of small poplars makes the section one very easily brought under cultivation. The river along this part of its course is not more than about 25 miles from the Canadian Northern railway.

The only exposures of hard rock in situ other than the sandstones before described occur about 40 miles above the Red Earth Indian reserve, where fissile, soft grey shales, containing enough bituminous matter to constitute a bituminous shale, are exposed in cliffs about 15 feet high. These shales dip to the southwest at a low angle. The remains of fishes, and other fossils contained in them, and their close resemblance to the Pas Mountain beds, show them to be referable to the Niobrara division of the Cretaceous.

West of range 13, occasional homesteads are met with, occupied for the most part by Norwegians, who appear to make good settlers and who successfully raise grain and mixed crops.

Reindeer Lake.

The lake is in the neighbourhood of 150 miles long and, in the northern part, its width averages about 30 miles. From the southern end, where the lake is narrow, great bays run off on each side, which have not been explored, and about 75 miles of the east shore has not been traversed. In the southern part the shores are generally precipitous and the land rises to heights of from 200 to 400 feet above the water. At the northern end the land is low, sandy, and barren and is without hills. The forest growth about this part of the lake is small and consists almost exclusively of scrubby black spruce and birch. The soil cover is very scanty everywhere, though at a few points small patches of clay occur. To the south the shores are fairly well wooded, the forest growth including among other species, aspen poplar, which is not found to the north. Islands in great number and of all sizes fringe the shores and chains of them traverse some of the wide stretches from shore to shore.

[1]"The rock near the northeastern part is chiefly a red granite. On the western shore a reddish granite-gneiss with large porphyritic crystals of feldspar is the prevailing rock. The foliation runs about southwest, though local variations from this are found. Bands of a whitish granite, which may be intrusive, are seen on some of the small islands, as well as dark dioritic patches which also appear to be intrusions. On the east side, the same granitic-gneiss was seen,

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[1] Geol. Surv., Canada, Annual Report, 1895, Vol. VIII, Pt. D.

and near Porcupine point the foliation is more distinct, the large crystals of feldspar being arranged more in the form of interrupted bands. Intrusive veins of a light flesh coloured pegmatite cut the gneiss. The same intrusive granite is seen again on a point at the west side 16 miles north of Priest's point. It is in the form of a large boss, and is coarse in texture, with the peculiar arrangement of the quartz which gives the appearance of graphic granite.

'The western shore from Vermilion point was followed southward, so that the eastern shore is still indefinite. The numerous islands are nearly all bosses of rock more or less rounded by glacial action and covered with a slight growth of small spruce, the immediate surface back from the water-mark being generally carpeted with a thick growth of the light yellow reindeer moss. Though these islands are usually high, the mainland is generally still higher, and often the main shore is easily traced because bare from forest fires, while all the islands, with a few exceptions, are still green. To the south, and especially in the narrow portion, both the hills forming the mainland on both sides and the islands appear to rise higher than at the north, giving that part of the lake a very picturesque appearance. The timber also, in the south, is of a more varied nature. There, spruce, poplar and birch are found, but north of the middle of the lake poplar is rarely seen and the small spruce is the principal tree.

'The rocks at Vermilion point are of spotted red granite-gneiss, which extend northward to the limit of the lake and appear in about the same position, the beds standing at a high angle running S.W. and N.E. At Thompson island, the largest and highest south of Vermilion point, they give place to a series of hornblende mica-gneisses, followed on the point to the south by finer, laminated beds approaching schists. These to the east are found to alternate with granite, and for a considerable distance south, to near Priest's point, the rock is a banded series of granites and thin beds of mica-schist broken into by the graphic granite mentioned previously. Near Thompson island the beds run W.S.W. and E.N.E., but again in a short distance are found slightly twisted or wavy, although preserving a general parallel strike to that first noted.

'From Priest's point, the lake gradually narrows from a minimum width of four miles to a narrow inlet less than a mile wide at the outlet, and the course of this part lies very nearly S.W. and N.E., following in a general way the strike of the rocks. A band of dark mica-schists is crossed, reaching from near Priest's point to 20 miles S.W., and along the course followed through the islands many small dykes of a quartzose, fine-grained granite were found, in which iron pyrites is freely developed. The beds of fine-grained gneiss on Camping island, 10 miles south from Priest's point, are also found with many veins of pyrites, and on the hill in the centre of the island many of the beds are very much rusted and decomposed. The pyrites is found to contain a small percentage of nickel and traces of cobalt. At the north side of a small creek on the west shore, southwest from Camping island, the Indians report a soft soapstone or serpentinous rock from which they make pipes, but a visit to the locality did not result in finding this rock, which was then said to be obtained in small pieces from the shore and generally under the water. The rock there was, however, a light green sericite-schist, and it is possible that unfoliated or less cleavable portions of this might be soft enough for the purpose named. The stratigraphical relations of this band with the surrounding gneisses could not in the time at the disposal of the party be made out, so that it is problematical whether this may be a small area of highly altered Huronian beds or not. The next rock occurring to the south is a dark garnetiferous gneiss, followed by reddish granitic gneiss to the outlet of the lake.'

Wollaston Lake.

'Wollaston lake is a large body of beautifully clear, transparent water lying in a general north-and-south direction, with a greatest length of about 55 miles, and an approximate area of 800 square miles. Its contour is exceedingly irregular, its shore-line being indented by deep bays, and its surface dotted with numerous rocky islands. Two tributaries were discovered flowing from the southwest into its western side, while it holds the unique position, for so large a lake, of being drained by two almost equal streams which flow in opposite directions.' Stone river, one of these, flows to Lake Athabaska and the Arctic ocean, and Cochrane river, the other, to Reindeer lake, on the Hudson Bay watershed. Only the west shore of the lake has been traversed. 'The bay of Wollaston lake, from which Stone river flows, is a mile and a half long and three-quarters of a mile wide,' . . . 'the shore is generally lined with boulders, but there are a few little stretches of sand' . . . . 'The beach is a line of boulders, behind which the country is low and wooded with small black spruce. Three miles south of the head of Stone river is an esker-like ridge of sand and boulders between 200 and 300 feet high, lightly wooded with Banksian pine. Behind a little sandy bay near its south end a deep, mossy bog stretches up a gentle slope to the edge of a terrace of rounded gravel 60 feet above the lake, marking an ancient lake shore.

'A mile southeast of this sloping bog a long and narrow island lies in the mouth of a rounding bay. It is made up of very steep esker-like hills and ridges 70 feet high of sand and well rounded boulders, between which are deep kettle-holes, occasionally containing small ponds. The sides of the hills are as steep as the sand will stand, and their bases are fringed by rings of boulders.

'Following the shore onwards for four miles, the first rock in place met with was on a small island of red granite. The granite is composed chiefly of orthoclase and quartz, with a little plagioclase and biotite, and contains some inclusions of foliated gneiss. The surface is smooth, but, like most of the rock-surfaces in this region, it is not striated.

'For 10 miles southward, to the mouth of Collins creek, no rock was seen in place, but the shore is mostly strewn with boulders, many of which are of Athabasca sandstone and conglomerate. Behind the beach is a rather steep slope, rising from 10 to 20 feet, to a sandy plain wooded with Banksian pine, similar to the plain on the west shore of Cree lake. Many of the sandstone masses are quite angular, and their presence here, and not farther north, taken together with the general sandy character of the surrounding country, is conclusive evidence of the occurrence of Athabasca sandstone in the immediate vicinity. The occurrence of the sandstone here shows that this lake, as well as all the other large lakes through which we have passed, lies along the line of contact of the Archæan and Palæozoic rocks.

'Collins creek is, at its mouth, a small stream 45 feet wide, running over a bed of boulders. Its water is of a light brown colour, and its banks are grown with spruce and willows. It flows into the bottom of a long, narrow bay with beaches of sand and boulders.'

'We followed the low east shore of Collins bay outwards for 6 miles, to a point behind which is a high rounded hill of dark grey, well foliated biotite-gneiss, striking N. 20° E. and dipping S. 70° E. at an angle of 50°. In some places it is very coarse and full of biotite, and is much broken by irregular veins of coarse red pegmatite. Its surface is smooth, and shows strong glacial grooves, trending S. 10° W.

'Two miles and a half farther around the shore is a long point of massive, coarse, white granite, containing inclusions of dark biotite-gneiss, while just behind is a high rounded hill of dark grey biotite-gneiss striking N. 45° E. and with a vertical dip.

'From the top of this hill a magnificent view may be had of the lake. Towards the north and east it is dotted with many islands, while towards the south is an extensive stretch of clear blue water. Its shore-line is very irregular, and behind it rise low, gently sloping hills thinly wooded with spruce and pine, often separated by extensive swamps wooded with small spruce and larch.

'From this place we struck southward, at first past some points of white granite, and then for 5 miles straight across the open lake to the east point of a large wooded island, composed of greenish-black, thinly foliated, fine-grained hornblende-biotite-gneiss, striking N. 45° E. and dipping S. 45° E. at an angle of 75°. Interlaminated with the gneiss are some bands of white quartz. The surface is smoothed, and on the summit are glacial grooves trending S. 15° W. In the last stretch the water in the lake was found to have an average depth of 28 fathoms, with a greatest depth of 32½ fathoms.

From this island we crossed for 3 miles to a small bare island of massive, very coarse, white granite, consisting chiefly of quartz and orthoclase, with a small quantity of biotite, and black tourmaline in large crystals. A mile and a half farther on, is a large island of similar white, but finer grained, granite. Two miles farther is a long bar of boulders, forming the north point of a very large rocky island or peninsula. A mile and a half farther south, we camped on a boggy spot at the foot of a hill on the south side of a point, in north latitude 58° 7′ 40″. The hill is 250 feet high, and is composed of a coarsely granular, red biotite-gneiss, foliated N. 65° E.

'For 9 miles farther south, the shore is very irregular and composed of similar reddish gneiss rising in hills from 100 to 300 feet in height, with a fairly persistent strike, N. 40° to 65° E. The summits and southwest sides of many of these hills are covered with sand and boulders. Wherever glacial striæ were observed they trend S. 30° W.

'From here we turned southwestward for 8 miles, along the strike of the gneiss, in a channel from a mile to two miles wide, between a large island to the east and the low shore to the west, but whether of a large island or of the mainland was not determined. This shore is thickly strewn with boulders, and low exposures of reddish-grey gneiss were seen at but a few places. Some wooded islands lying off the shore are low and chiefly composed of boulders.

'From the end of this channel we struck westward, past some red granite islands piled around with boulders, to a sandy beach where Indians had lately been camped. High sand hills rise here and there, and banks of sand, being sections of these sand hills, occur at various places along the shore, but their faces are so covered with talus that nothing could be determined from them as to the structure of the hills. Among the pebbles found on the beach was one of white crystalline limestone.

'From this sand beach we turned eastward for 2½ miles, to a point, and then southward down the west shore of Nekweaza bay, which is 14 miles in depth. The shore is composed of similar red granite and gneiss, and some of the islands lying off it are narrow, esker-like ridges of sand. On the evening of August 23rd, camp was pitched on the shore in north latitude 57° 48′ 48″, on a gravel beach 10 feet above the lake. Just behind the camp was an old gravel shore-line 5 feet higher. Towards the southwest was a swamp lying on a bed of boulders, beyond which was a high rounded hill, wooded with spruce and pine. Its centre consists of a reddish gneiss, while almost all the surface is covered with a fine reddish sand or silt, holding a large number of rounded boulders.

'Nekweaza bay, running southwestward to the mouth of Geikie river, is broken on its western side by many smaller bays, but its eastern side seems to be more regular, and part of the shore near the main lake is nearly straight, terminating at the north in a low point, off which is a series of long, low, narrow islands. Down the centre of this bay a string of islands stretches from near the mouth to the eastern shore at the bottom of the bay. Those which were visited seemed to be made up entirely of drift, and, judging from their shape, many of the others are of like material. They lie S. 25° W., with their longest diameters nearly parallel and approximating to the general direction of the glacial striæ. The striæ observed on the eastern shore run S. 30° W., or more nearly parallel to the side of the valley.

'Several of the low narrow islands off the point and in the bay to the east are also of drift and have the same general orientation. The larger ones and the main shore are of Archæan gneiss and granite, and have bold shores.

'The hills bordering the south shore of the lake are high, but slope gradually from the beach, with the exception of those at the entrance to Compulsion bay, where they are much steeper, rising to nearly 200 feet. East of the bay higher hills are seen, some probably reaching 400 feet above the lake.

'The rock exposures near Geikie river are of dark grey gneiss, foliation running S.W. to S. 55° W., but near the mouth of Nekweaza bay this is broken into by a red unfoliated granite, and then eastward the granite seems to have replaced the darker rock, though in places a slight foliation was noticed.'

[1] Southern Indian Lake.

The lake lies on the course of Churchill river. It extends northeasterly and southwesterly from north latitude 57° through, in all, about one degree. Though its shore line encloses an area of 800 square miles it nowhere shows any wide expanse of open water; the wider parts are broken by many islands and the bays are long, narrow, and crooked. Its representation on earlier maps is based on track surveys by Peter Fidler, an explorer for the Hudson's Bay Company, and gives, with some degree of accuracy, the outline of the part of the lake traversed by an explorer journeying up or down the Churchill river, though the lake is assigned a much greater width than it has by the extension of some of the bays to form islands of the larger points projecting from the west shore. The extreme length of the lake is 92 miles and at the broadest part, 8 miles from the foot, it is 15 miles wide. Just north of the wide expanse it becomes restricted to a width of one mile, and through the narrows a fairly strong current flows. About the central part of the lake and extending inland from the east shore the land is covered with a mantle of friable, yellow clay. Towards the north end, beyond where the Churchill flows out, sand replaces the clay and forms level tracts 70 feet above the level of the lake, extending southeasterly, but broken here and there by low hills and dunes and showing ridges of rolled, coarse gravel that seem to mark old lake beaches. At the very north end and down the northwest shore for 20 miles the land is quite low and covered with a thick growth of moss and stunted black spruce and tamarack. Into this part of the lake come great herds of barren ground caribou, which on their annual winter migration come into the north end of the lake from the northwest, travel southwesterly down about half its length, and, if the snow is not too deep, strike from there westerly to Reindeer lake. In winters when the snowfall has been unusually great the herds partly break up, large bands, in order to escape the deep snow, turning off to the north again instead of following the customary circuit. A river of large volume known to the Indians as Muskwesi (Grass river) flows into the lake from the northwest at Grassy bay, about 8 miles from the head, and two large brooks enter on the east side, one 12 miles north of the outflow of Churchill river and another 20 miles south of it; in addition, smaller brooks empty into many of the bays about the lake, but are much less plentiful on the west side than elsewhere.

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[1] See also under detailed description of Churchill river.

Reed Lake.

Reed lake is about 12 miles long and 6 miles wide. It combines the features characteristic of the lakes of the Pre-Cambrian area and those of the limestone area.

The northern portion of its basin, lying in an area of Keewatin rocks, has a deeply indented shore-line and many islands, while the southern portion, bordered by limestones, has a much more even contour and very few islands. The land surrounding the lake is generally quite low, and to the south is covered by a mantle of drift with occasional low ledges of limestone. The northern part is characterized by rocky shores with many irregular points and bays and a great number of small islands.

The forest about the shores includes poplar, white birch, jackpine, spruce, and tamarack of 35 years' growth, with a few small areas of older trees. Fish are plentiful in its waters and of good quality.

Cormorant Lake.

Cormorant lake is a strikingly beautiful body of clear, blue-white water, 15 miles long and 10 miles wide. A few large and many small islands form a chain running southeasterly and dividing the lake into two nearly equal expanses of open water. The remaining islands, except two of fair size near the southwest end, are small and lie near the shore.

The greater part of the shores of both mainland and islands is formed of limestone that rises from the water in low cliffs 6 to 10 feet high and extends out into deep water in wharf-like shelves. Most of the mainland has been burned over within recent years, but the islands and part of the shore, especially on the north side, are covered with a good growth of large white spruce. The lake is well stocked with fish, including lake trout and whitefish.

The land in the vicinity of the lake is generally not more than 50 feet above the level of the water surface, but a broad point on the east side near the outlet rises to a height of almost 100 feet.

Atikameg Lake.

Atikameg lake, which flows into Cormorant lake by a short, rapid stream, is roughly rectangular in shape and about 7 miles square. It has much the same general character as the larger lake, though its expanse is unbroken by islands, except a few small ones near the shores. No large stream flows into the lake, which seems to be fed largely by seepage through the gravel ridges which border it to the south and southwest.

Amisk Lake.

Amisk lake is a roughly rectangular body of water 18 miles long by 12 miles wide. The southern half is broken by only a few islands, but the northern half is nearly all occupied by one large island around which the lake wraps in a narrow belt. This is one of the numerous class of lakes which are strung along the edge of the Palæozoic sedimentary rocks, lying partly in them and partly in the Pre-Cambrian. All the northern shores of the lake are well wooded, principally with spruce which over certain areas is of good size. The south shore and part of the east shore are underlain by magnesian limestones, which in many places show cliff faces front-ing the water. The rest of the shore lies in the Pre-Cambrian and shows generally smoothly sloping surfaces, though a part of the country adjoining the east shore, which is underlain by massive diorites, is rugged and rises abruptly from the water with steep slopes and in places precipitous walls.

The forest, over all the region surrounding the southern portion of the lake which is crossed by the main boat route, has been repeatedly swept by fires; but to the north a large area is still covered by spruce of good size.

Whitefish and lake trout are plentiful in the lake.

GLACIATION.

The whole region covered by the map-sheet has everywhere over its surface abundant evidence of glaciation by ice-sheets of vast extent. Boulder-clay and morainic and other accumulations of transported material, *roche moutonnée* surfaces and glacial grooves, striæ and chatter-marks are among these evidences. Whether these in any case record other than the latest phases of glaciation or not cannot be determined, though it seems probable that they do not.

The records that are left seem to show that the whole area was overridden by an extensive glacier that moved over it in a direction a little west of south and that the eastern part was, at a later period, traversed by an ice-sheet moving about westerly, and that, finally, there were local sheets that moved in directions differing from the first two. Striæ left by the southwesterly moving ice are the most abundant, not only in the area under consideration but over the whole country extending from Lake Athabaska to east of the Great Lakes, and seem to indicate movement from a general gathering ground that covered the whole region to the north. The southwesterly striæ, though they keep a uniform general direction, vary from the average direction by many degrees. This divergence of direction, though in places representing the deflection of the ice-sheet by local topographical features, in most cases represents changes in its general direction. To illustrate, on Southern Indian lake, two general directions are followed by most of the striæ, namely, S. 37° W. and S. 55° W., and there are striæ about the south and east shores of the lake trending about S. 70° W.; in a few instances all three sets are found on the same rock surface. Along Burntwood river and in the Grass River district, in addition to later, westerly trending striæ, there are two well marked sets following the directions S. 20° W. and S. 45° W.

The later ice-sheet which moved from the east terminated westerly, so far as the records of striæ in the district indicate its extension, at the southeast end of Southern Indian lake on Churchill river, at Threepoint lake on Burntwood river, at Wekusko lake on Grass river, and just west of the Pas on the Saskatchewan. In the Churchill area the most westerly locality at which glacial drift, that seemed clearly attributable to the eastern ice, was found was on the east shore of Southern Indian lake. Over a belt east of this line marking the edge of the eastern glacier, the striæ from the east are lighter and override on the same rock surfaces the earlier set. Just west of the same line an area of country along Burntwood river shows but slight signs of having been glaciated, there is much rotted and broken rock at the surface and no striæ, and on Churchill river an area characterized by many sharply angular blocks of the underlying rock. There are striæ, too, along a parallel line a little farther west which have a direction differing from the prevailing one on either side, though, since striæ with similar courses are found in other parts of the district, their occurrence along this line may be without significance. On Churchill river at Granville lake and for a short distance above they run about S. 30° E.; below Burntwood lake, S. 10° W., and on Wekusko lake, S. 8° W.

Striæ that are thought to have been made by the glacier in its dying stage and to represent movements from local centres, are certain southerly trending ones seen on the east side of Lac LaRonge, overriding southwesterly striæ, the south~~westerly~~ easterly trending striæ of Granville lake and the nearly southerly striæ of upper Burntwood river and Wekusko lake, overriding southwesterly striæ. There is, however, between these a certain accordance of direction which is found also in certain striæ recorded by Bell[1] and Brock[2] as overriding westerly ones on Hayes river, which may indicate they were made by lobes of an extensive sheet moving in that direction.

Striæ along the shore of Hudson bay at Churchill and farther north show an ice-movement outwards towards the bay that may also represent a movement from local centres near the close of the period of glaciation. Tyrrell, however, from the angular character of the seaward facing cliffs along the coast section as far south as

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[1] Report of Progress, Geol. Survey, Canada, 1877-78.
[2] Summary Report, Geol. Survey, Canada, 1910.

Fort Churchill, contrasted with the well rounded hills in the vicinity of Churchill, concluded that, though in the southern area the outward movement succeeded a general glaciation from the east, in the northern area there was no evidence of an earlier westerly movement.[1]

Boulder-clay is not widely distributed over the area; to the northeast it covers a somewhat extensive area bordering Hudson bay. Over the Pre-Cambrian area it is represented by small accumulations of boulders lying under the lee of southerly facing cliffs.

In the southern part of the district boulder-clay is fairly widespread; in the Saskatchewan valley it forms the prominent ridges at the Pas and Big Eddy, and forms islands in Saskeram lake.[2] On Carrot river, at the lower rapids the river has worn its channel deeply into boulder-clay, and in Ballantyne bay, at the northeastern edge of the area of deep superficial deposits, it forms high scarped cliffs on some small islands. It occurs high up on the north and east sides of the Pasquia hills, 1,000 feet or more above the Saskatchewan valley.

Glacial Striæ.

SOUTHERN INDIAN LAKE.

South shore Sta. 1			S 57° W		
" " 4	S 37° W				
" " 14			S 54° W		
" " 33			S 52° W		
" " 41			S 54° W		
" " 83	S 20° W	and	S 56° W		
" " 88			S 55° W		
" " 96	S 20° W	and	S 56° W		
" " 97	S 32° W	to	S 47° W	and	S 72° W
S. end of southeast bay					S 82° W
Island in southeast bay	S 37° W		S 47° W	and	S 72° W
East shore Sta. 138	S 37° W			and	S 62° W
" " 141 (old fragmentary)	S 27° W		S 49° W	and	S 62° W
" " 162	S 36° W	and	S 52° W		
" " 216	S 19° W				
Northeast shore Sta. 254	S 30° W				
" " 294	S27° W				
West shore Sta. 416			S 47° W		
" " 458	S 17° W				
" " 553			S 47° W		
Southwest shore Sta. 613			S 42° W	and	S 59° W
" " 696					S 69° W

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[1] Annual Report Geol. Survey, Canada, Vol. IX, p. 177 F.

[2] Ann. Rept. Geol. Survey, Can., Vol. XIII, p. 16 FF.

CHURCHILL RIVER.

South shore of			
Granville lake	S 21° E		
Granville fall	S 37° E		
10 miles above Granville fall	S 23° E		
Nelson lake 10 miles north of Elbow	S 17° W		
Nelson lake at Elbow	S 18° W		
9 miles east of Pukkatawagan	S 38° W		
Bloodstone portage		S 52° W	
Guncoat bay			S 70° W

AMISK LAKE.

Southeast shore	S 23° W		
Northeast shore	S 19° W		

STURGEON-WEIR RIVER.

Spruce portage	S 5° W		

BIGSTONE LAKE.

North shore	S 10° W		

MIROND LAKE.

South end	S 20° W		

DESCHAMBAULT LAKE.

North shore	S 15° W		
Northwest shore	S 14° W		
6 miles from south end	S 25° W		
3 “ “	S 20° W		

NELSON RIVER.

1 mile above Sipiwesk lake		S 58° W	
3 miles above Sipiwesk lake		S 51° W	
Narrows, Cross lake		S 58° W	
1 mile below Pipestone lake		S 52° W	
1 mile above Pipestone lake	S 61° W		
Sea-horse fall		S 56° W	

BURNTWOOD RIVER.

3 miles below Odei river		S 47° W and	later S 87° W
5 miles above Elbow (light)			N 73° W
9 miles above Elbow “			N 63° W
Summit of Odei portage “			N 63° W
2 miles below Apussigamasi lake			N 73° W
Foot of Apussigamasi lake			S 83° W
Middle of Apussigamasi lake			S 68° W
6 miles from head of Apussigamasi lake			N 82° W
5 miles below Manazo fall			N 63° W
Birch lake			N 87° W
Fall above Wapishtigau brook			N 62° W
1 mile above fall of line above			N 78° W

Foot of Opegano lake			S 88° W
4 miles below Waskwatim lake			N 87° W
5 miles above Waskwatim lake		S 41° W	
Threepoint lake		S 48° W	
2 miles above Threepoint lake		S 48° W	
10 “ “ “	S 16° W		
11 “ “ “	S 15° W		
Winter portage to Pasquia	S 20° W		
1 mile below Wimapedi brook...... (heavy)	S 26° W		
Moosenose fall	S 9° W and (occasional)	S 46° W	
Metuss fall	S 14° W		
Minehik rapid	S 14° W		
2 miles below Grindstone rapid	S 23° W		
Grindstone rapid	S 22° W		
Muddywater river	S 38° W		
Moose portage...... (light)	S 43° W		
5 miles below Duck rapid	S 38° W		
3 “ “	S 38° W		
2 “ “	S 40° W		
Asippitti river	S 41° W		
6 miles below Burntwood lake ..... (heavy)	S 21° W		
4 “ “ “	S 21° W		
Foot of Burntwood lake	S 27° W		
Middle of Burntwood lake	S 26° W		
Mouth of File river	S 26° W		

FILE RIVER.

2 miles from mouth	S 28° W
3 “ “	S 28° W
On Hill 5 miles from mouth	S 38° W
Foot of Limestone Point lake	S 36° W
Head of File lake	S 28° W
East shore of File lake	S 30° W
Methy lake	S 28° W

GRASS RIVER.

First lake below Reed lake at inlet	S 43° W		
First lake below Reed lake opposite inlet	S 28° W		
Middle of first lake below Reed lake	S 48° W		
Reied lake near outlet	S 42° W		
Foot of first lake below Reed lake	S 28° W		
Head of Wekusko lake...... (heavy)	S 8° W and S 28° W		
Head of Wekusko lake, summit of ridge	S 8° W and S 28° W		
East shore, north end Wekusko lake	S 30° W		
East shore, ⅔ way up Wekusko lake	S 6° W and S 28° W		
Yawningstone lake (with chatter marks)			S 88° W

CORMORANT LAKE.

North shore, 3 miles east of inlet			S 76° W
North shore, 4 miles east of inlet			S 78° W
North shore, 5 miles east of inlet			N 82° W
Northeast shore			S 78° W
Northeast shore, near outlet	S 28° W	S 58° W and	S 83° W
Northwest shore			S 83° W
West shore			S 73° W
West shore, island near (with chatter marks)			S 63° W S 83° W N 72° W

West shore, 2 miles N. of Clearwater portage	S 64° W S 73° W S 83° W
West shore, 1 mile N. of Clearwater portage.	S 65° W S 72° W S 77° W S 83° W

CLEARWATER LAKE.

2 miles south of	S 80° W

LAC LARONGE.

Pipe bay, northwest shore of	S 19° W	
Pipe bay, east shore of	S 27° W	
Island near north end	S 3° W	
North shore of	S 20° W	
Nemeiben river	S 36° W	
Nemeiben lake, north bay of	S 25° W	
Island N.W. of Trout narrows	S 3° W	
Trout narrows, at shore		S 57° E
Trout narrows, on hill (old fragmentary)	S 33° W later	S 47° E
Trout bay, 2 miles east of narrows	S 18° W	
Trout bay, 3 miles S.E. of narrows	S 37° W	
Southeast shore (with chatter marks)	S 18° W	

WAPAWEKKA LAKE.

South shore		S 47° W
North shore	S 27° W	
Northwest shore	S 18° W	

Additional lists of glacial striæ may be found in the reports of Bell,[1] Upham,[2] Tyrrell,[3] and Dowling.[4]

Potholes.

Potholes are not uncommon throughout the district. One at the outlet of Southern Indian lake has a diameter of 4 feet and a depth of over 6 feet; the rim is 10 feet above the foot of the present fall and 8 feet below its crest. The rock is biotite granite gneiss.

On the west side of the long, river-like northeasterly bay of Lac LaRonge, which is called Pothole bay, two potholes appear in section on a cliff face of banded biotite gneiss which extends downwards into deep water. They lie side by side, and only about a quarter-section of each remains. The larger is about 20 feet deep and, estimating from the part of its section left, had a diameter of 15 feet. The section of the hole extends from the surface to within about 7 feet of the present level of the water in the bay. On the west side of Footprint river, north of Threepoint lake, a pothole is exposed in half-section on the cliff face of gneiss; it has a diameter of 4 feet and is 6 feet deep. The present channel of the river is cut to a depth far below the bottom of the pothole. The valleys or gorges on the sides of which the Lac LaRonge and Footprint River potholes occur are pre-glacial, or are earlier than all the records of glaciation that are preserved, since both the west trending and southwest trending striæ occur in them.

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[1] Geol. Surv., Canada, Reports of Progress, 1877-78 CC, 1878-79 C, and 1879-80C.
[2] Geol. Surv., Canada, Annual Report, Vol. IV., Pt. E., 1888-89.
[3] Geol. Surv., Canada, Annual Report, Vol. V., Pt. E, 1890-91; Vol. VIII, Pt. D, 1895; Vol. IX, Pt. F., 1896; Vol. XI, Pt. G., 1898, and Vol. XIII, Pt. F., 1890.
[4] Geol. Surv., Canada, Annual Report, Vol. XI, Pt. F., 1898, and Vol. XIII, Pt. FF, 1890.

Tyrrell has recorded the occurrence of potholes on an island in Playgreen lake and on the west shore of Wintering lake[1]; also at the third portage north of Pelican lake, on the route to Churchill river by way of Frog portage, where 'many of the potholes are clearly pre-glacial, the glacier having broken their northern and smoothly rounded their southern edges. The southern edge of the large pothole shows this smoothing very clearly.'[2]

In the neighbouring area lying east of Lake Winnipeg, Tyrrell also records potholes in the valleys of Berens and Bloodvein rivers. In the case of Berens river, these occur on the southwest side of a rocky point where the rock descends more or less abruptly into deep water. 'The outer half of one is cut away almost vertically and the face of the cut cliff is strongly scored by glacial grooves."[3]

Potholes on the Bloodvein river 'show rims broken on their northeast and rounded on their southwestern sides, indicating an age at all events previous to the last glaciation, perhaps interglacial."[4]

In the region north of Lake Superior, the occurrence of a series of potholes on the east side of a steep hill of dark green hornblende rock, 1½ miles back from the lake shore, has been recorded by Peter McKellar. 'The western or mountain side of many of the holes stand up above the front side, in some cases as much as 30 feet or more. . . . . . In one place horizontal glacial grooves may be seen on a portion of the elevated, vertical wall of the potholes."[5]

It would seem most probable, from a consideration of these facts, that the records that are now preserved in this area of the

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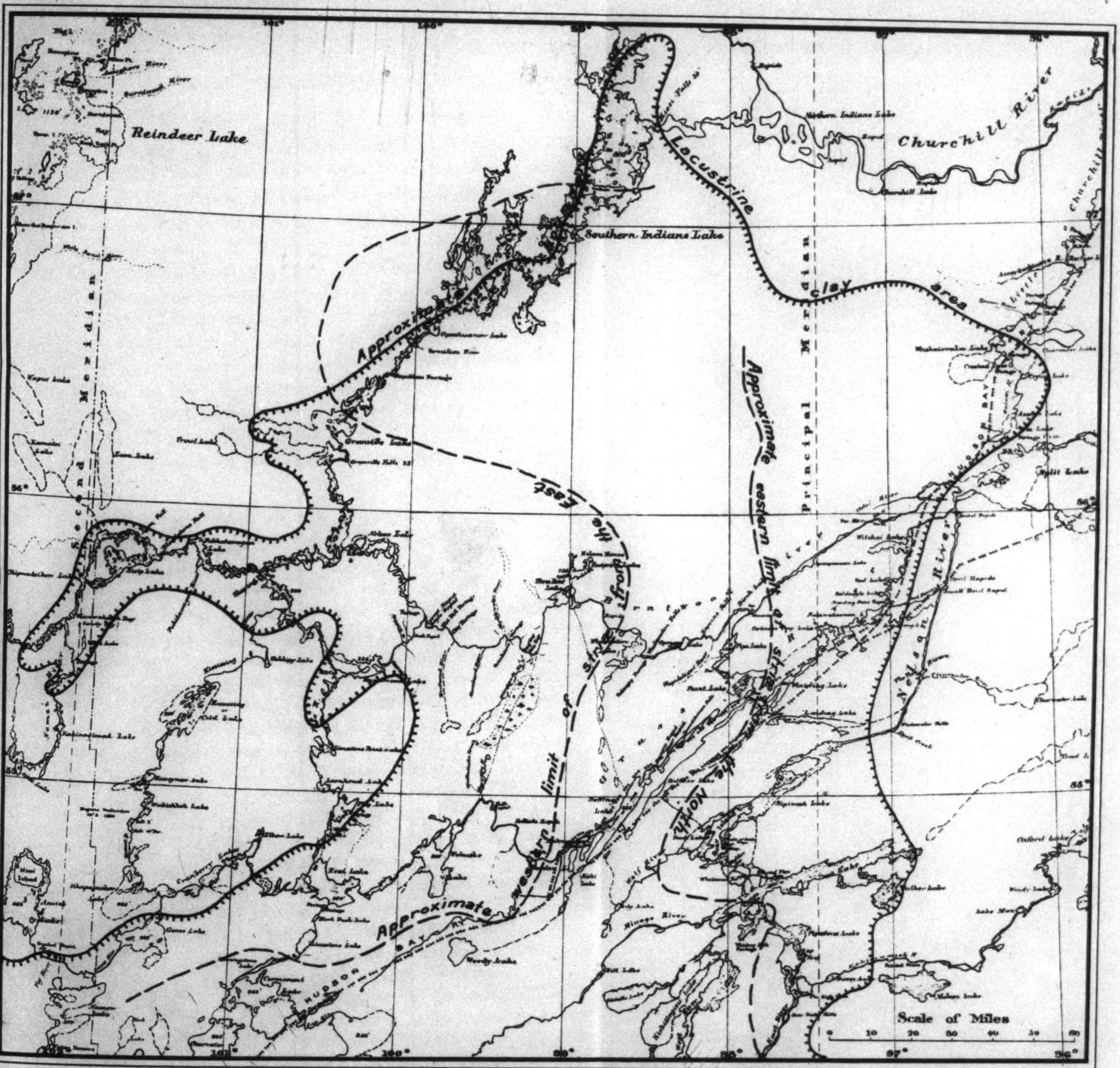
[1] Ann. Rep. G. S.C., Vol. XIII, p. 30 F.
[2] Ann. Rep. G. S.C., Vol. IX, pp. 103 F–104 F.
[3] Ann. Rep. G. S.C., Vol. XI, p. 37 G.
[4] Ann. Rep. G. S.C., Vol. XI, p. 43 G.
[5] Bull. Geol. Soc. Am., Vol. I, pp. 568–570.

Department of Mines—Geological Survey.


Reindeer Lake
Churchill River
Northern Indians Lake
Churchill Lake
Southern Indians Lake
Lacustrine clay area
Approximate
Approximate
western limit of strand lines
Approximate eastern limit of strand lines
East front of the
the North
Principal Meridian
Second Meridian
Granville Lake
Nelson River
Split Lake
Oxford Lake
HUDSON BAY
Scale of Miles
0
10
20
30
40
50
60
54°
55°
56°
57°
58°
97°
96°
98°
99°
100°
101°
102°

Diag. Northern End of Glacial Lake Agassiz

To accompany Memoir No. 30.

many diverging directions of glaciation may all be ascribed to late stages of glacial time, and that the potholes were formed at an early inter-glacial period, for the amount of erosion that took place after the hollowing of the potholes and before the passage of the glaciers which left the existing striæ must have required a very long time for its accomplishment.

The age of the potholes may even be pre-glacial; they may represent work accomplished by the cascades of a drainage system which only here and there and largely fortuitously corresponds with that of the present, which as a result of profound erosion and of differential changes of elevation has been almost entirely changed.

The absence in the case of some of the potholes, of a filling of materials carried by the glacier in its passage over them may be explained by the fact that they probably were filled with ice before the glacier reached them and continued so for some time after its retreat.

LAKE AGASSIZ.

A very large area within the region covered by the map-sheet has a surface mantle of friable clay of a very uniform character, and over large areas quite free from enclosed boulders or gravel.

These deposits show evidence, in their uniform composition from top to bottom and in the absence of stratification, of continuous deposition, and are, therefore, considered to be deposits accumulated by sedimentation in a lake basin. These clays, in a part of the area, notably in the country about the lower stretches of Burntwood river, are thick enough to completely fill the old valleys and to convert a country of once rolling surface into an almost level plain. Along Burntwood River valley, which occupies part of a more ancient trough, the clays now cover the hills to a height of 150 feet or more above the level of the river. Farther west, along the upper courses of the same river and of its tributaries, where the elevation above sea-level is about 935 feet, the clay occurs only to a thickness of a few feet in the bottoms of the valleys, and isolated depressions among the surrounding hills which are not connected with the river valleys, are free from it. No distinct beaches mark the edges of the ancient lake where the clay thins out in this direction, a feature perhaps to be expected where the valleys seem to represent long, narrow arms of a lake in which the water would be comparatively undisturbed, and which were occupied by it for a short time only.

At about W. longitude 97° where the bottom of the river valley is about 480 feet above sea-level, the clays in the valley seem to have their greatest thickness, and from that point westerly as the valley gradually rises the thickness of the clay diminishes, and in W. longitude 100°, at an elevation of 935 feet, its western edge is probably reached.

On the northern and probably also on the eastern side the shore line does not follow a contour of the surface, since in these directions the water of the lake was held in by ice barriers formed by the fronts of the receding continental glaciers. The lacustrine character of these clays was recognized by Tyrrell[1] and Dowling,[2] who describe them as they occur over a part of this area, and attribute them, without doubt correctly, to glacial Lake Agassiz which Upham[3] had before traced northward from Minnesota through part of Manitoba.

In a report on northwestern Manitoba, Tyrrell describes the beaches of the western shore of the lake in their extension northward along the faces of the escarpments formed by the Riding, Duck, and Porcupine mountains. On Duck mountain he found the highest strand to have a height above sea-level of 1,365 feet. The measurements of strand lines by Upham in Minnesota and southern Manitoba established a rate of progressive elevation northerly, or more exactly north-northeasterly, for the upper beaches averaging about one foot to the mile or increasing from about 6 inches in Minnesota to over a foot in central Manitoba. Tyrrell's highest beaches on Duck mountain seem to indicate that the rise per mile continues to increase through northern Manitoba. The occurrence of marine clays in the valleys of rivers draining into Hudson and James bays[4] at elevations of about 400 feet above sea-level affords further and positive evidence of this post-glacial elevation of the northern portion of the continent. On the Porcupine mountain the highest levels at which these beaches were observed by Tyrrell and Dowling were slightly lower than the level of the highest beaches on Duck mountain.

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[1] Geol. Surv., Canada, Annual Report, New Series, Vol. XIII, Pt. F.
[2] Geol. Surv., Canada, Annual Report, New Series, Vol. XIII, Pt. FF.
[3] Geol. Surv., Canada, Annual Report 1888-9, Vol. IV, Pt. E.
[4] G. S. C. Annual Report, New Series 1901, Pt. F.
Dept. of Mines, Geol. Surv. Branch, 1910, Winisk River report.
Geol. Surv., Canada, Rep. of Progress, 1878-9, Pt. C.

On the face of the Pasquia hills ridges of rolled coarse gravel which probably represent a continuation of these beaches were observed, but their heights were not determined.

All the higher beaches seem to have been formed during the earlier part of the life of the lake, when the discharge was southerly and when the country north of the Saskatchewan was still covered by a thick mantle of ice which formed the northern boundary of the lake.

The lacustrine clays of the area north of the Saskatchewan on the other hand are the result of sedimentation which went on in a much restricted lake, after the water had fallen far below the level of the old southerly outlet but before the elevation had been accomplished.

That the lake in the region north of the Saskatchewan never stood at the high level indicated by the beaches to the south is clearly shown by the absence there of lacustrine deposits, that seem to be attributable to this period of sedimentation, at levels higher than about 935 feet; and that the deposits in the northern area were laid down prior to the elevation of the land is shown by the fact that since they were deposited in a glacier-dammed lake they must antedate the marine clays of the Hudson Bay slope, which being found at the high levels before referred to must have been laid down before the elevation.

ECONOMIC GEOLOGY.

Although no mineral industry is yet carried on in the area, there is reason to hope that, when better means of access have been provided, more thorough exploration will result in their development. No part of the region has been closely prospected, and most of it has not yet been even visited by the prospector. The various belts of Keewatin and Huronian rocks, described in other pages, from the experience gained in areas of similar rocks elsewhere in Canada, for example in the Cobalt and Porcupine areas, in the Thunder Bay and Rainy River districts, and in other localities, must be looked upon as affording promising fields for the search for valuable minerals. In the newer rocks, the oil-shales of the Pasquia hills are of some promise, and the discovery of the occurrence of coal, north of Prince Albert, may be followed by the finding of seams of commercial importance.

Gold.—There have been, so far as known, no discoveries of gold in quantity sufficient for mining, but more thorough prospecting of the areas of Keewatin rocks may yet reveal its presence. In Ontario, where the areas of similar rocks have been more closely examined, they have in many cases been found to contain gold in sufficient quantity for economic mining, and in a few cases in bonanza amounts.

Silver.—Mr. Brock, in the Summary Report of the Geological Survey, 1910, states:—

'Mr. Wm. Ogilvy, of the Department of the Interior, has informed me that galena, carrying 25 ounces of silver to the ton, has been found on a lake north of Nelson House, near the divide between Burntwood and Churchill rivers.'

The specimen was examined by F. G. Wait, of the Mines Branch, who reports: 'The sample, which weighed but 8 grammes, was submitted to assay and found to contain:—

Gold—none.

Silver—at the rate of 24 ozs. 10 dwts. to the ton of 2,000 lbs.'

Copper.—Chalcopyrite has been found at a number of localities within the area covered by the map-sheet, though nowhere in quantity sufficient for its commercial development. It has been recorded from Lac LaRonge,[1] from File lake,[2] and from Nelson river[3]; also the writer found a sample of grey copper in possession of an Indian at Pukkatawagan on Churchill river, which he alleged, probably with truth, he had found on the shores of a small lake south of the Churchill a short distance to the east.[4]

Molybdenum.—Samples of molybdenite have been found in possession of the Indians from time to time,[5] and rounded, crystal aggregates of that mineral were found by Tyrrell in red pegmatite, at a point on the shore of Little Playgreen lake just below where the Nelson river flows from it.[6] Dobbs notes its occurrence on the Echimamish river.[7]

Iron.—Though iron-ore has not been found in quantity, the occurrence of the rocks, which characterize the iron-bearing portion of the Keewatin, known as the iron formation, has been noted at many points in the region, or their presence has been conjectured from abnormal deflections of the magnetic needle, and boulders of banded iron ore, probably from the Huronian, are not uncommon. In the Journal of the Geological Society of London, 1821, a description is given of a number of specimens of rock collected in 1812 by Abel Edwards, surgeon at the Red River settlement, while on a journey from Lake Winnipeg to York Factory. A specimen from an island in Knee lake is described as oxidulous iron; 'the compass does not traverse when passing this island.[1]

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[1] Summary Report of Geol. Survey, 1908, p. 92.
[2] Summary Report of Geol. Survey, 1906, p.95.
[3] Geol. Survey, Canada, Vol. XIII, 1900, p. 24 F and 25 F.
[4] Summary Report of Geol. Survey, 1908, p. 90.
[5] Geol. Survey, Canada, Summary Report, 1908, p. 90.
[6] Geol. Survey, Canada, Annual Report, Vol. XI, 1898, p. 16 G.
[7] Geol. Survey, Canada, Summary Report, 1905, p. 71.

Sir John Franklin writes, in all probability in reference to the same locality.[2]

> 'About half a mile from the bend or knee of the lake there is a small, rocky islet, composed of magnetic iron ore, which affects the magnetic needle at a considerable distance. Having received previous information in respect to the circumstance, we watched our compasses carefully, and perceived that they were affected at the distance of three hundrd yards both in the approach to and departure from the rock; on decreasing the distance they became gradually more and more unsteady, and on landing they were rendered quite useless; and it was evident that the general magnetic influence was totally overpowered by the magnetic attraction of the ore. When Kater's compass was held near to the ground on the N.W. side of the island, the needle dipped so much that the card could not be made to traverse by any adjustment of the hand; but on moving the same compass about thirty yards to the west part of the islet, the needle became horizontal, traversed freely, and pointed to the magnetic north. The dipping needle was landed on the S.W. part of the islet, was adjusted as nearly as possible to the magnetic meridian by the Sim's bearings, and found to vibrate freely, when the face of the instrument was directed to the east or west. The mean dip it gave was 87° 37′ 50″. When the instrument was moved from the N.W. to the S.E. point, about twenty yards distant, and placed in the meridian, the needle ceased to traverse, but remained steady at an angle of 60°. On changing the face of the instrument, so as to give a S.E. and N.W. direction to the needle, it hung vertically. The position of the slaty strata of the magnetic ore is also vertical. Their direction is extremely irregular, being much contorted.'[3]

In an appendix to the same journal, by Sir John Richardson, it is stated that—

> "the magnetic island referred to on page 36 of the narrative is composed of the same rock (mica slate) highly impregnated with magnetic iron ore and having its thin layers alternating with layers of that mineral.'

Bell reports, 'on the south side of the inlet of Knee lake layers of fine-grained magnetite iron are interstratified with grey silieeous and micaceous schists running about east and west. . . . . A small islet in this current (narrows) and the western shore abreast of it consist of fine-grained magnetite iron in thin layers, interlaminated with others of quartzite and mica schist.' [1]A sample of the ore from Magnetite island was examined by Dr. Hoffmann,[2] who described it as, 'Massive, structure very fine granular, almost compact. Laminated. Colour bluish-grey. Lustre dull. On examination was found to contain: metallic iron, 45·86 per cent. This specimen was perfectly free from titanic acid.'

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[1] Trans. Geol. Soc. of London, 1st. Ser., Vol. V, 1821.

[2] A journey to the Shores of the Polar Sea in the years 1819, 20, 21, by John Franklin, R. N. F. G. S., p. 36.

[3] Ibid, p. 303.

Beds of magnetic iron ore interstratified in siliceous slates are recorded by Dr. Bell as occurring where Trout river falls into the head of Knee lake.[3] Cochrane mentions finding the rocks very highly magnetic at an island called Iron island, near the north shore of Island lake.[4]

Low says of the belt of Keewatin, which he mapped on the upper stretches of Severn river, that 'The rocks in several places are highly magnetic, and probably contain large amounts of iron ore, both disseminated in small crystals through the rock and in large masses."[5]

Brock[6] noted the occurrence, at various points on the same belt of Keewatin rocks, of beds which resembled strongly the 'iron ore formation' of the eastern Keewatin. There can be little doubt, therefore, that in the belt of Keewatin rocks which extends from Cross lake on the Nelson, through Oxford lake to Knee lake, is incorporated a band of rocks of the 'iron ore formation.' The examination of a sample of the ore, quoted above, shows that it is of good quality though not very rich. It would seem that there is here a tract of country that it would be worth while to prospect for richer deposits of iron ore.

Clay ironstone beds occur in the upper part of the Niobrara beds of the Cretaceous of the Pasquia hills, but the iron content is probably too low to render them valuable commercially. An analysis of a sample gave[7]:—

Metallic iron..	29·10 per cent.
Insoluble mineral matter..	9·20 "

On the east shore of South Indian lake a large, loose, almost sharply angular block of interbanded jasper and hematite was noted, lying on a glaciated surface of gneiss. The angular character of this block made it seem probable that it had not been carried very far from its point of origin, though rocks of Keewatin or Huronian age are not known to occur in the neighbourhood. In a conglomerate on the shore of a small lake, east of Reed lake, on Grass river, an angular block of jasper, resembling 'iron ore formation', was observed. The rocks from which it was derived were not located.

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[1] Geol. Surv., Canada, Report of Progress 1877-78, pp. 21 and 22 CC.
[2] Geol. Surv., Canada, Report of Progress, 1878-79, p. 15 H.
[3] Geol. Surv., Canada, Report of Progress, 1878-79, p. 36 C.
[4] Geol. Surv., Canada, Report of Progress, 1878-79, Pt. C.
[5] Geol. Surv., Canada, Annual Report, Vol. II, Pt. F.
[6] Ante page.
[7] Geol. Surv., Canada, Summary Report, 1907, p. 45.

It may be said, then, that though iron ore in quantity large enough for commercial exploitation has not been found in the area under consideration, there is good reason to believe that the rocks of the 'iron ore formation' occur at many points, and there is a fair probability that prospecting for iron in the district will result in the discovery of deposits of commercial value.

Sulphide.—The occurrence of iron-sulphide has been noted at various points along one or other of the Keewatin belts; and at Lac LaRonge and on Churchill river deposits occur of a size that make them of prospective value as possible sources of sulphuric acid or sulphur.[1]

Coal.—The occurrence of seams of lignite on the south shore of Wapawekka lake, northeast of Prince Albert, was noted in the Summary Report of the Department for 1909.

The coal occurs in horizontal beds in the quartz sands and sandstones of the Dakota division of the Cretaceous. Carbonaceous matter occurs in many narrow streaks in the sandstone but only one seam of any size is exposed. This crops out along the scarped face of sand for a distance of 3½ miles, following the curving shores of the most southerly bay of the lake. At its widest point the seam has a total thickness of 4 feet 1 inch, but is divided in the middle by a 6 inch, sandy parting (Plate XIX). Where it is cleanest, at the most southerly outcrop, the thickness is 2 feet 5 inches, of fairly clean lignite. Northwesterly from the outcrop last named the seam thins out or is represented by very dirty lignite or highly carbonaceous beds of sand. Northeasterly from the same outcrop it seems also to thin out, but, owing to the higher encroachment of talus on the cliff face in that direction, its extension is concealed.

A proximate analysis by fast coking of a sample of this lignite, made by F. G. Wait of the Mines Branch, Department of Mines, gave the following results:—

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[1] Geol. Surv., Canada, Summary Report, 1908, p. 90 et seq. and 1909, p. 151 et seq.

Moisture	11·23	per cent.
Volatile combustible matter	30·97	"
Fixed carbon	34·80	"
Ash	23·00	"
	100·00	"
Coke, non-coherent	57·80	per cent.
Fuel ratio	1:1·13	"
Split volatile ratio	1·88	"

Colour of ash—light orange.

Another analysis was made by Mr. Wait, of a sample received in 1907, and described as 'from an unsurveyed area northwest of Cumberland lake, Saskatchewan.' The sample probably comes from the same seam or from a seam occurring in the same Cretaceous sandstone elsewhere in the neighbourhood. The analysis gave the following results:—

Moisture	13·25	per cent.
Volatile combustible matter	28·97	"
Fixed carbon	24·80	"
Ash	23·00	"
Coke, non-coherent	57·78	per cent.
Fuel ratio	1:1·19	"
Split volatile ratio	1·76	"

These analyses show that the coal is a lignite of fairly good quality, since it is probable that the high ash content is largely due to included sand.

The fact that the coal is cleanest at the most southerly exposure, in the bight of the bay, makes it seem probable that the improvement may continue southerly, and that south of the lake, where, owing to the horizontal attitude of the beds and the lack of scarped cliffs there are no outcrops, coal of higher quality may be found.

Coal, probably the same seam or a similar one, has been found by prospectors at several points on the lakes lying at the head of Bowtree river, south of Lac LaRonge.

On Athabaska river, seams of lignite 2 feet in thickness have been noted in the so-called tar sands which, like the beds under consideration, are thought to be of Dakota age.[1]

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[1] Geol. Surv., Canada, Vol. V, Pt. D.

Photo by W. McInnes, 1909.

Lignite seam, Wapawekka lake, Saskatchewan. (Mr. Firth is standing at the foot of the seam with his hand resting on the top.)

The coal-bearing horizon of the Dakota has, therefore, a wide distribution, though the beds do not belong to any of the divisions of the Cretaceous that have been recognized as important coal-bearing horizons.

Oil-shales.—A great thickness of shale, of Niobrara age, which is exposed on Carrot river and on the northern and eastern slopes of the Pasquia hills, is oil-bearing. The beds have a thickness of upwards of 150 feet and lie about horizontal, so that they, with little doubt, underlie the hill throughout its whole extent. An analysis of a sample of this shale, taken at hazard, was made by Mr. Leverin, of the Mines Branch, Department of Mines, with the following result:—

Sulphate of ammonia.. ..	22·5 lbs. per ton.
Crude oil..	7·0 imp. gals. per ton.

The value per ton of shale would, therefore, be approximately $0.85.

For purposes of comparison, the values, in oil and ammonia, of other shales may be cited.

A test of samples of oil-shales from New Brunswick, aggregating 36 tons 15 cwts. in weight, made by the Pumpherston Oil Company, Scotland, gave:—

Sulphate of ammonia. ..	76·94 lbs. per ton.
Crude oil..	40·09 imp. gals. per ton.

This would give a value of, approximately, $3.50 per ton of shale.

Another set of analyses, made by Mr. Leverin, of the Mines Branch, of samples from bands of shale from the vicinity of Albert Mines, New Brunswick, gave an average of:—

Sulphate of ammonia.. ..	68·9 lbs. per ton.
Crude oil..	43·3 imp. gals. per ton.

Dr. Ells, in the report from which the last two averages have been taken,[1] says: 'Generally, in Scotland, the cost of mining and retorting the shale—while varying considerably in different places owing to local conditions—is about $1.86 per ton, divided as follows:—

Mining and taking to retort mouth..	$1 00
Retorting..	40
Manufacture of sulphate of ammonia.. ..	46
	$1 86

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[1] Dept. of Mines, Joint report on the Bituminous or oil-shales of New Brunswick and Nova Scotia, 1910.

It will be seen from the figures quoted above that the sample analysed does not indicate, for the Pasquia Hills shale, a content of sufficient value to warrant working. It must be said, however, that the sample analysed was taken without reference to its richness as an oil-shale sample, and that, in the 150 feet or more of the shale underlying the hills, there may very well be beds much richer both in oil and sulphate of ammonia.

It may be noted that in Manitoba the shales of the upper portion of the Niobrara, which are highly calcareous, are used in the manufacture of cement.

Mica.—Crystals of mica 9 inches in diameter have been observed in a pegmatite vein[1] on Cross lake, but it has not been found anywhere in the district under conditions which give promise of its being of commercial value.

Salt.—About the base of the Pasquia hills, just north of the edge of the Cretaceous escarpment, many saline springs occur which derive their salt, presumably, from the underlying Silurian limestone. A spring on the left bank of Carrot river, about 20 yards back from the stream, just above the crossing point of the 14th base line, has been long known to the Indians and used by them in the manufacture of salt by evaporation.

Henry, ascending the Saskatchewan in 1808, records that at the entrance to Carrot river ‘we found a freeman tented. He had passed part of the summer up the river where there are several salt springs, and had made a considerable quantity of salt which he had brought to dispose of to our men on their way to the interior where this article is not found.[2] The water in the spring above referred to is slightly milky in appearance, strongly saline to the taste, and gives off a very noticeable odour of sulphuretted hydrogen.

Of a sample from this spring which he examined, Mr. Wait says:—

‘As received the water, about one quart, contained a trifling quantity of pale, brownish-white, flocculent, organic matter in suspension, which was removable by filtration. The filtered water was clear, bright and colourless. To the taste it was strongly saline. It was devoid of any distinctive odour and reacted neutral, both before and after concentration. Its specific gravity at 15·5° C. was found to be 1·024; pure water being 1·000. The total dissolved saline matter dried at 180° C., in 1000 parts by weight of the filtered water amounted to 28·14 parts; equivalent to 2017·07 grains per imperial gallon. A qualitative examination showed the presence of:—

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[1] Geol. Surv., Canada, Vol. IX, p. 33 A.

[2] The manuscript Journals of Alexander Henry and of David Thompson, 1797–1814. Edited by Elliot Coues, 1897.

Potassa	very small quantity.
Soda	large quantity.
Ferrous oxide	trace.
Lime	small quantity.
Magnesia	small quantity.
Sulphuric anhydride	rather small quantity.
Carbonic anhydride	small quantity.
Chlorine	large quantity.
Silica	very small quantity.
Organic matter	not detected.

Boiling produced a small precipitate, consisting principally of calcium carbonate, with a little magnesium carbonate, and a trace of ferrous carbonate.'

'The quantity of water available was too limited to admit of search being made for bromine, iodine, baryta, or strontia or boric acid.'

'The principal saline constituent of the water is chloride of sodium. A proximate determination of the chlorine showed that 100 parts by weight of the water contains 15·465 parts of that element; which quantity is equivalent to 25·48 parts of chloride of sodium.'

Similar springs in northern Manitoba have been utilized for the manufacture of salt. This spring is a little lower in salt content than most of the springs in Manitoba, but is higher than some.

Amber (Retinite, Chemawinite).—A species of amber or retinite has been found mingled with sand on bars near the head of Cedar lake, Saskatchewan river.[1] Tyrrell, who visited the locality in 1891, found pieces as large as a robin's egg and smaller particles, mingled with beach sand and fragments of decayed wood. In parts of one beach, a little less than a mile in length, it made up 10 per cent, by volume, of the material of the beach.

B. F. Harrington who described it,[2] says: 'The substance was in pieces, for the most part very irregular in shape, some being more or less angular, others approximately spherical and others flattened, discoid or lenticular. Some of the pieces were smaller than a pea, but they ranged from this up to the size of an ordinary bean (about 2 centimetres long). In colour they varied from pale yellow to dark brown. . . . . Some of the larger pieces of the Cedar Lake resin might, perhaps, be employed for ornamental purposes (beads, etc.), and possibly the material might be utilized by the varnish maker,

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[1] Geol. Surv., Canada, Annual Report, Vol. V, Pt. E.

[2] American Journal of Science, Vol. XLII, Oct. 1891.

. . . . . there can be but little doubt that it has been derived from one of the Tertiary or Cretaceous lignites occurring on the Saskatchewan.'

Glass Sand.—Quartz sand, that seems well adapted for use in the manufacture of glass, makes up a large part of the Cretaceous beds to the northeast of Prince Albert. Where they are exposed on the shore of Wapawekka lake, they consist of horizontally bedded, loosely coherent, white sandstone and sand, exposed in high scarped cliffs. The quartz grains are subangular and are fairly uniform in size, about 93 per cent passing through a 60-mesh sieve. An unwashed sample, collected from the face of the bank, was analysed by Mr. Leverin. It gave the following result:—

SiO_2 (silica).	98·60 per cent.
FeO_3 (iron oxide), Al_2O_3 (alumina)	1·20 "
Other impurities.	0·20 "
	100·00 "

The cliffs of sand are 30 to 40 feet high, facing the lake, and are so loosely coherent as to be easily reduced and collected by the hydraulic method. Washing, as may be seen from the analysis given above of the unwashed sample, would render this sand very pure indeed.

Lime.—Limestones, suitable for burning for the manufacture of lime, are plentiful along a broad zone, just north of the Saskatchewan. They are the magnesian limestones of the Palæozoic which form a broad belt between the Cretaceous escarpment and the Pre-Cambrian, except where, in the western part of the area mapped, the Cretaceous beds are lying directly upon the Pre-Cambrian. In that part of the area, a band of crystalline limestone in the Pre-Cambrian at the north end of Lac LaRonge is quite suitable for lime making.

In the northern part of the area the rocks of the Palæozoic basin of Hudson bay are mostly limestones.

Clay.—Much of the lacustrine clay of the district would probably make good red bricks. The clays of a belt of country running east from Cormorant and Reed lakes, and extending down Grass river, seem to be particularly well adapted for this purpose. A pipestone, occurring on Wapawekka lake, would probably furnish good material for firebrick.

Samples of these clays were submitted to laboratory tests by Mr. J. Keele, who has furnished the following report, showing that a good common brick may be made from them:—

CLAY LABORATORY.

Report on Two Samples of Clay submitted by Mr. McInnes.

(1) Lab. No. 1832. A loamy non-calcareous surface clay, from valley of Wuskataska river, Saskatchewan.

When mixed with the proper amount of water this clay develops fairly good plasticity, but gives a rather short working body owing to the presence of much fine grit.

The air shrinkage of the green bricklets made from it was 5·3 per cent.

The burning tests are as follows:—

Cone.	Per cent fire shrinkage	Per cent absorption.	Colour.	Hardness.
010	0·7	20·0	Red.	Near steel hard.
03	11·0	0·0	Brown.	Vitrified.
1	Fused.			Fused.

This clay yields a good common brick at cone 010.

(2) Lab. No. 1833. A calcareous surface clay from Wuskwatim lake, Saskatchewan.

This clay when tempered with water was of rather low plasticity, the body was rather 'short' and open, much gritty material present.

The air shrinkage was 5·6 per cent.

In burning it behaved as follows:—

Cone.	Per cent fire shrinkage.	Per cent absorption.	Colour.	Hardness.
010	1·0	24·8	Salmon.	Near steel hard.
03	12·0		Brown.	
1	Fuses to a slag.			

This clay gives a fair common brick at cone 010.

Neither of the above clays are suitable for the manufacture of vitrified wares, as their melting points are too near their vitrification temperatures.

As these two samples of clay were taken from near the surface, the above tests do not give the real value for the clay deposit. The deposit would have to be worked to a much greater depth in brickmaking.

Building Stone.—The dolomites of the Ordovician and Silurian, which are exposed over a wide belt of country north of the Saskatchewan, in many cases are very suitable for building purposes, and occur in beds of almost any desired thickness. In the Pre-Cambrian area many of the granites are suitable for this purpose. A granite which occurs on the first expansion of Grass river, below Reed lake, is of a very bright red colour and even texture, and seems well adapted for dressing and polishing.

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CANADA

DEPARTMENT OF MINES

HON. LOUIS CODERRE, MINISTER; A. P. LOW, DEPUTY MINISTER;

GEOLOGICAL SURVEY

R. W. BROCK, DIRECTOR.

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Memoirs and Reports Published During 1910.

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Report on the geological position and characteristics of the oil-shale deposits of Canada. By R. W. Ells. No. 1107.

A reconnaissance across the Mackenzie mountains on the Pelly, Ross, and Gravel rivers, Yukon and North West Territories. By Joseph Keele. No. 1097.

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